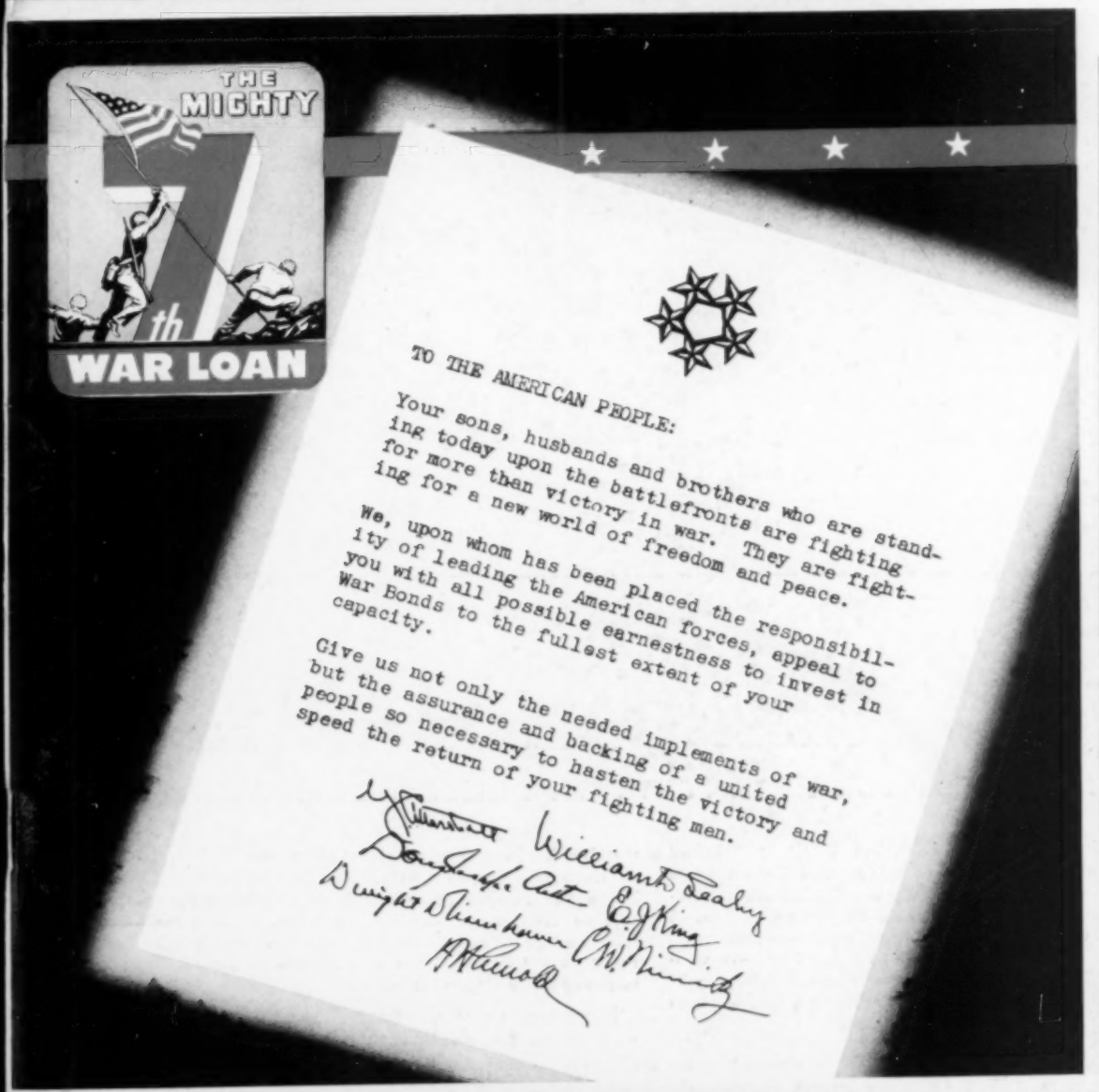
Compressed Air Magazine

JUNE 1945


THE MIGHTY
7th
WAR LOAN
TO THE AMERICAN PEOPLE:
Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.
We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.
Give us not only the needed implements of war, but the assurance and backing of a united people so necessary to hasten the victory and speed the return of your fighting men.
Dwight D. Eisenhower
C. W. Nimitz

VOLUME 50 • NUMBER 6 NEW YORK • LONDON

This bulb screen in Wisconsin paper mill has load peaks similar to those of an air compressor and finds belt tension control essential.

"All belt drives need belt tension control"

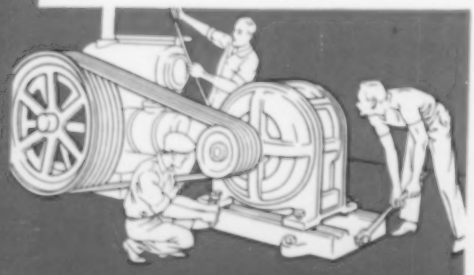
ROCKWOOD automatic belt tightening MOTOR BASES

BELT TENSION CONTROL ESSENTIAL ON BELTED COMPRESSORS

For belt driven compressors—either V-belt or flat belt driven—**if you want top performance and lowest costs** YOU HAVE TO HAVE BELT TENSION CONTROL. Otherwise as the belts stretch (and they all do—sooner or later—) they become too loose and slip at load peaks—which wears them out. Then the compressor speed falls off—its capacity to produce air is reduced.

With Rockwood automatic tension control base under the motor **the belt tension automatically matches the load through all its changes**—the belt is never too loose—always just the right tension to prevent slip. **This keeps the compressor running at maximum speed, increases compressor capacity, decreases drive maintenance and practically doubles the life of the belts.** Also power is put to effective use—**compressor performance is improved and dependable.**

Belt tension control was originated and pioneered by Rockwood in their Rockwood pivoted motor bases. They are used in all industries and are essential for belt driven machines—particularly compressors. Available from stock for most motors to 60-75 h.p.—from semi-stock to 250 h.p.: and larger sizes made to order. Needed for either flat or multiple V-belt drives.



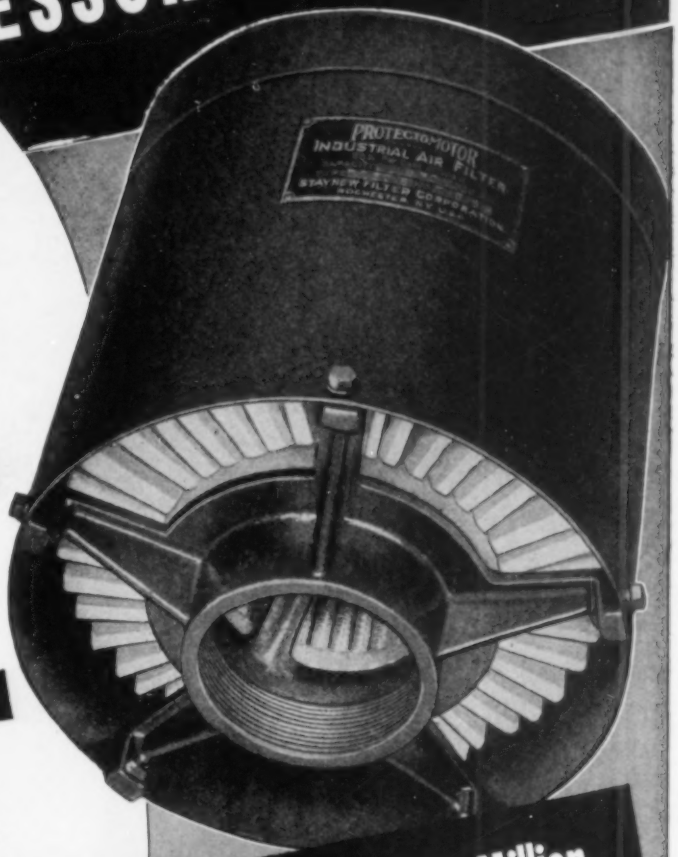
Costly shut downs for manual belt tightening are a thing of the past—too wasteful of time and labor. Thanks to the Rockwood pivoted motor base belt tightening is now made automatic. Belts that stretch are automatically re-tightened—and neither too tight nor too loose—but just right to suit the varying load. Considered the biggest improvement ever developed for electric motor belt drives. For use with either V-belts or flat belts.

ROCKWOOD

INDIANAPOLIS • U. S. A.

Specialists in Power Transmission Equipment Since 1884

WHY PROTECTOMOTOR INTAKE FILTERS ARE BEST FOR AIR COMPRESSOR USE



★ HIGH EFFICIENCY WHEN INSTALLED

Protectomotor Air Filters for internal combustion engines and compressors feature dry-type filtering media. These media are selected to fit particular installation conditions. They have been scientifically tested in the laboratory and proven by field use. Used in combination with the patented Radial Fin Insert Construction, they provide highest operating efficiency.

★ INCREASED EFFICIENCY WITH USE

Protectomotor filtering efficiency actually *increases* when dust begins to accumulate on the surface of the media, since this forms a precoating or filter-aid of the very material which is being handled.

★ LOW RESTRICTION TO AIR FLOW

Protectomotors at maximum ratings offer initial resistance to air flow of less than ½" of water. Since the exclusive Radial Fin Construction provides a maximum of filtering area, this resistance is held to a minimum throughout the life of the filter.

★ SERVICING SELDOM NECESSARY

The Protectomotor is a masterpiece of simple, rugged construction. There are no moving parts, no reservoirs, no liquids. The extremely large active filtering area reduces cleaning to an absolute minimum for any given set of conditions. When required, cleaning is quickly and easily accomplished by vacuum, compressed air, or washing.

★ POSITIVE PROTECTION ★★★

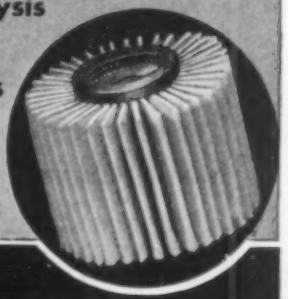
Inherent characteristics of the dry-type filtering media provide *positive* protection. Performance is *not* dependent upon periodic renewal of viscous coatings or other filter aids. Ideal for dust storm areas.

★ EFFICIENT AT HIGH OR LOW TEMPERATURES

As the filtering media used are of the dry-type, peak efficiency is maintained under all atmospheric conditions. There is no oil to evaporate at high temperatures or to congeal at low temperatures.

More than Half a Million Installations on Internal Combustion Engines and Compressors since 1920

Write for Catalog and Data Blank for Free Analysis of your Requirements



Radial Fin Construction

STAYNEW PROTECTOMOTOR FILTERS

DOLLINGER CORPORATION
(Formerly Staynew Filter Corp.)
7 Centre Pk., Rochester 3, N. Y.

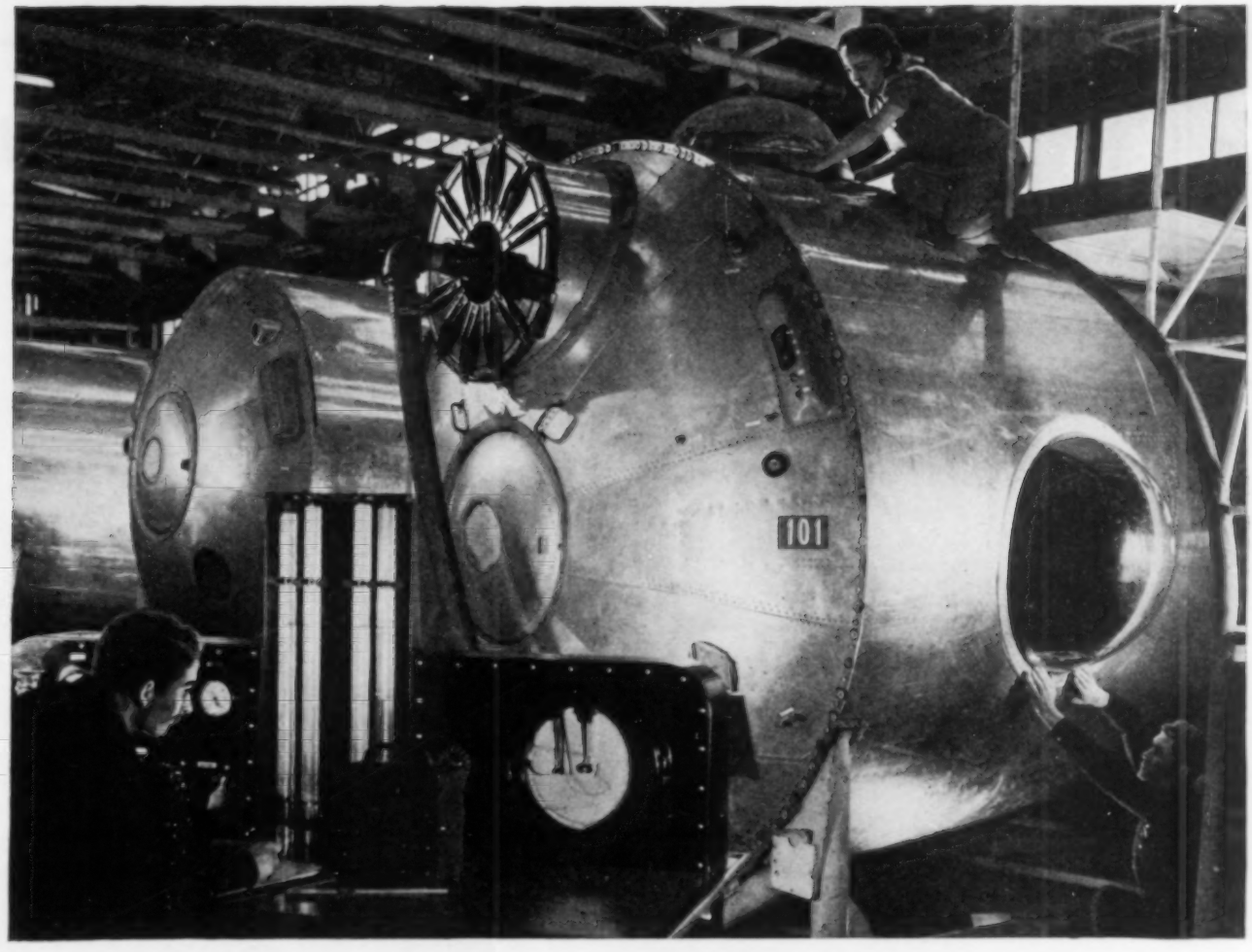
RESERVE...

Every Ingersoll-Rand machine is built to do more than just meet the specifications. High efficiency attained without sacrifice of durability, and strength far in excess of requirements, provide the reserves sufficient to meet any emergency.

COMPRESSORS
•
TURBO BLOWERS
•
AIR TOOLS
•
ROCK DRILLS
•
CENTRIFUGAL PUMPS
•
CONDENSERS
•
OIL & GAS ENGINES

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.



Working Under Pressure

PRESSURIZED cabins in B-29 Superfortresses enable crews to reach their targets in peak physical and mental condition principally by eliminating the need for using cumbersome oxygen masks that cause flying fatigue on long missions. To make certain cabins are airtight, they are tested with compressed air before installation, as shown.

Whether compressed air is used to test pressurized cabins or to power air tools, drills, hoists and other equipment, compressors operate more efficiently, require less maintenance when lubricated effectively. Experienced operators know this and so use Texaco.

Texaco Alcaid, Algol or Ursa Oils in compressors, assure wide-opening, tight-shutting valves, free piston rings, open ports, clear lines, continuous air supply. They also assure maximum service life between overhauls, fewer repairs and replacements. Their use in compressors is worldwide.

Texaco lubricants have proved so effective in service they are definitely preferred in many fields, a few of which are listed at the right.

Texaco Lubrication Engineering Service is available through more than 2300 Texaco distributing plants in the 48 States. Get in touch with the nearest one, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

THEY PREFER TEXACO

★ *More Diesel horsepower on streamlined trains in the U.S. is lubricated with Texaco than with all other brands combined.*

★ *More locomotives and railroad cars in the U.S. are lubricated with Texaco than with any other brand.*

★ *More revenue airline miles in the U.S. are flown with Texaco than with any other brand.*

★ *More buses, more bus lines and more bus-miles are lubricated with Texaco than with any other brand.*

★ *More stationary Diesel horsepower in the U.S. is lubricated with Texaco than with any other brand.*

TEXACO

TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

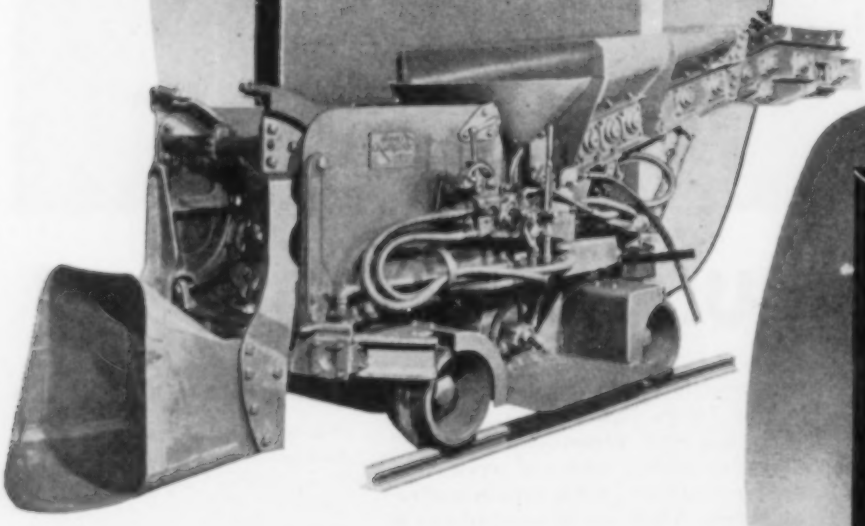
TUNE IN THE TEXACO STAR THEATRE WITH JAMES MELTON EVERY SUNDAY NIGHT—CBS

An Eimco RockerSho

for every loading job

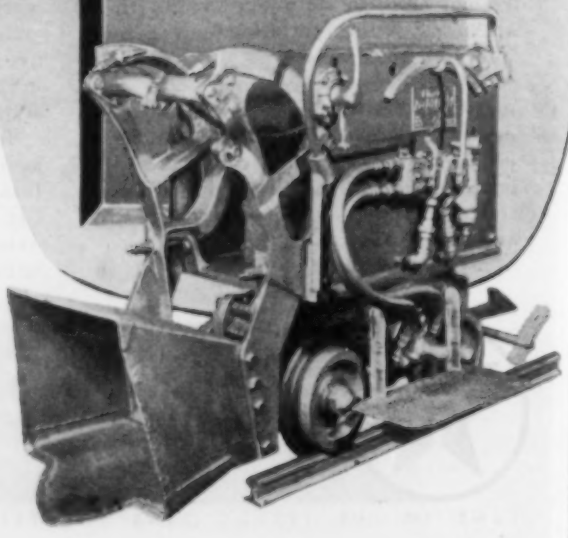
40

Weight 15,900 pounds, clean-up range 16 feet.
Loading speed 3-5 tons per min.
Track gauge—30" to 58½"
Air or electric powered models.



21

Weight 7400 pounds, clean-up range 10 feet
Loading speed 2-3 tons per min.
Track gauge—18" to 48"
Air or electric powered models.

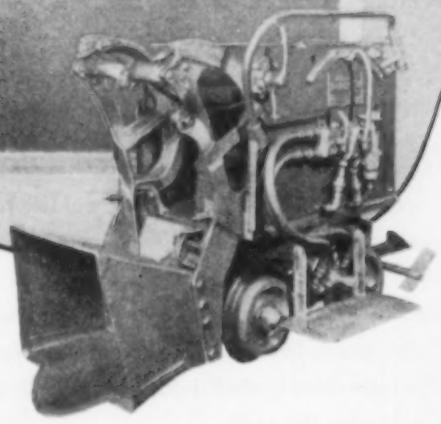


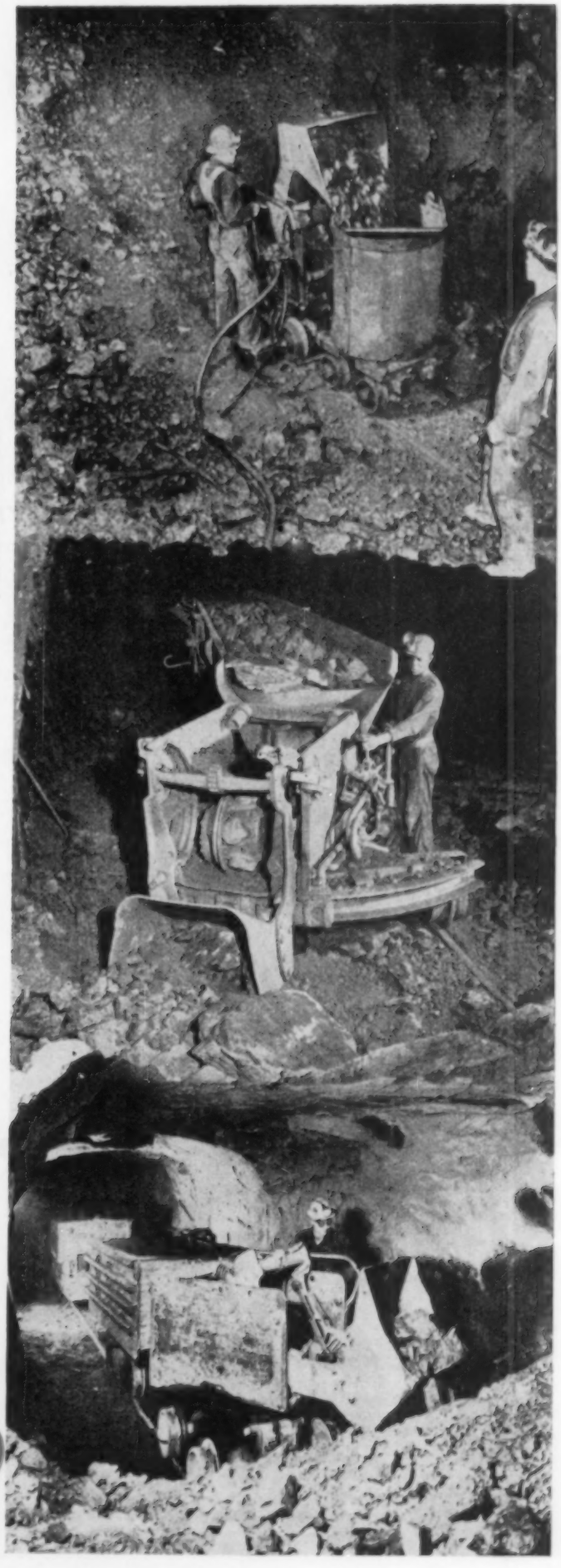
Eimco RockerShovel

vel

12B

Weight 4200 pounds, clean-up range 8 feet
Loading speed 1-2 tons per min.
Track gauge—15" to 36"
Air powered models only.





Because of its patented Rockerarm principle, Eimco is the only manufacturer of underground rock loading equipment producing a model for each job.

The same model by a different name will not efficiently handle a job that's twice too big for it.

The three RockerShovels illustrated are each built to cover a distinct field of work and each model is tailored to cover your conditions — couplers, buckets, dumping height, every part of the RockerShovel must be engineered to give a maximum of capacity with a minimum of up-keep.

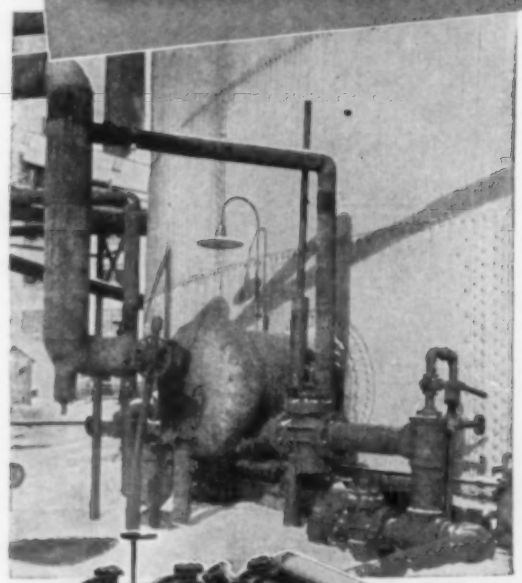
EIMCO

THE EIMCO CORPORATION

Executive Offices and Factories: Salt Lake City 8, Utah
Branches: New York, Chicago, El Paso, Sacramento, St. Louis

Speed up Oil Flow

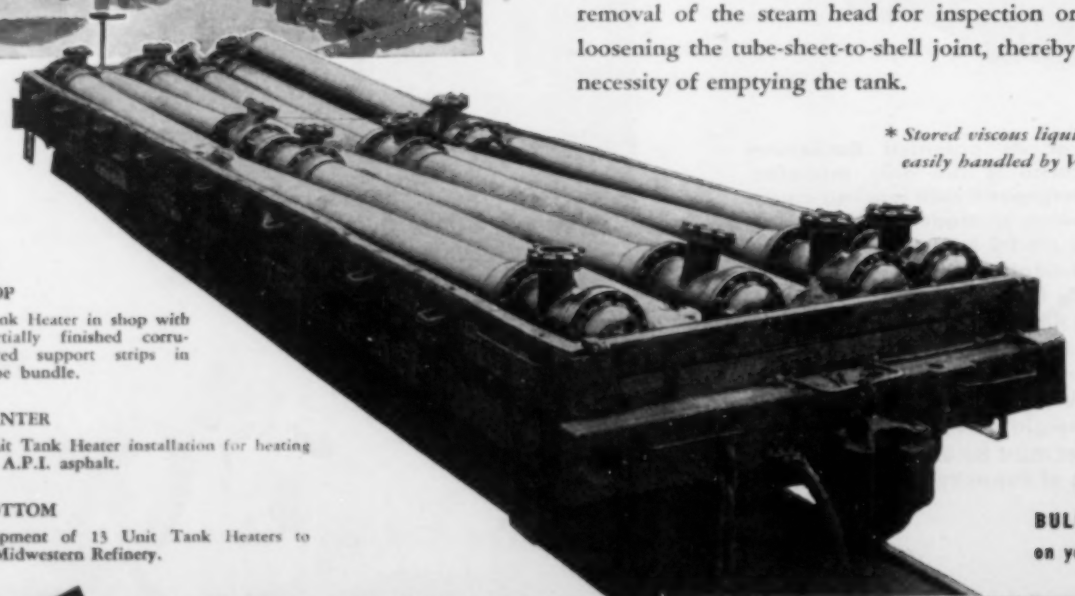
WITH Vogt UNIT TANK HEATERS*



SAVE TIME AND MONEY with Vogt Tank Heaters! They permit pumping to be started shortly after steam is admitted since only the small quantity of oil lying in the shell of a unit needs to be heated. As hot oil is withdrawn it is replaced by cold oil from the tank through the open end of the heater shell. Steam consumption is held to a minimum since *only* the oil removed from the tank is heated.

Standard Type U Heaters have nests of "U" bend tubes made from 1¼" seamless steel or 1" electric welded pipe, as desired. These are rolled firmly into tube sheets having double grooved tube holes. Corrugated strips support the tubes without impediment to the oil flow. Collar bolts permit removal of the steam head for inspection or repair without loosening the tube-sheet-to-shell joint, thereby eliminating the necessity of emptying the tank.

** Stored viscous liquids of any kind are easily handled by Vogt Tank Heaters*



TOP

Tank Heater in shop with partially finished corrugated support strips in tube bundle.

CENTER

Unit Tank Heater installation for heating 12 A.P.I. asphalt.

BOTTOM

Shipment of 13 Unit Tank Heaters to a Midwestern Refinery.

Write for BULLETIN HE-4 on your letterhead

HENRY VOGT MACHINE CO., INC., LOUISVILLE 10, KY.

Branch Offices: NEW YORK - CHICAGO - CLEVELAND - PHILADELPHIA - DALLAS

Lift YOUR LOADS
Lower YOUR COSTS

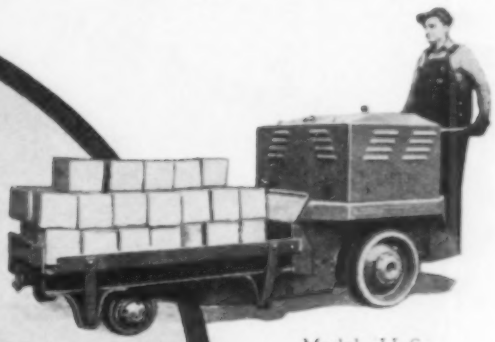
Put an **EASTON** Tier-Lift truck on the job. Watch it give your materials a lift—watch your handling costs go down.

Powered by storage battery or gas-electric Ready Power in capacities up to 10,000 pounds. **EASTON** trucks are easy to operate, economical to maintain—they stay on the job.

EASTON builds the original Tier-Lift electric truck. Backed by 30 years of experience the Tier-Lift, Low-Lift—also Platform and special types—solve unusual jobs.

Write Engineering Counsel, Easton Car and Construction Company, Easton, Pennsylvania.

Model - TLC-6



Model - LL-6

Model - TLC-6

A-1008

EASTON
INDUSTRIAL CARS
TRUCK BODIES • TRAILERS
ELECTRIC LIFT TRUCKS

BOILED DOWN

TO SIMPLIFY MOTOR SELECTION

● This new booklet gives ratings, sizes, characteristics, dimensions, where-to-use data, *and prices* of General Electric a-c and d-c motors, 1/16 to 75 hp. Everything you need to know to select these sizes—all in 16 pages!

Builders of TRI CLAD Motors

Buy all the BONDS you can—*and keep all you buy*

GENERAL ELECTRIC

To Save Your Time Later Mail This Coupon Today—

General Electric Company, Schenectady 5, N. Y.

Please send me a copy of your Condensed Motor Catalog (No. GEA-4281).

Name .....

Company .....

Address .....

City ..... **State** .....

T50-258-450

Here are construction advantages in *Twin Parallel Cables* you just can't overlook!

SECURITYFLEX

NO TWISTING! No failures due to one conductor riding over the other. The special D-shaped insulation prevents twisting.

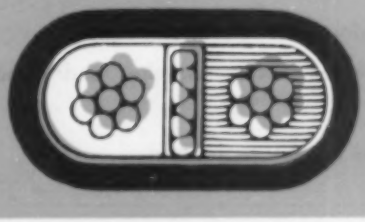
BREAKER STRIP! Separation of the conductors saves time and trouble in making connections and splices.

GREATER FLEXIBILITY! The herringbone compensating construction allows freer movement of copper conductor.

REINFORCED WEBBING! Tough Seine twine for extra strength prevents tearing of the jacket. Ask for detailed information at any of our sales offices.

SECURITYFLEX CABLE WITH SELF-CONTAINED GROUND WIRE

This special cable is only slightly larger in diameter. Standard lengths can be accommodated on the usual conductor reels. Loaders, conveyors, cutters, etc., are easily grounded.



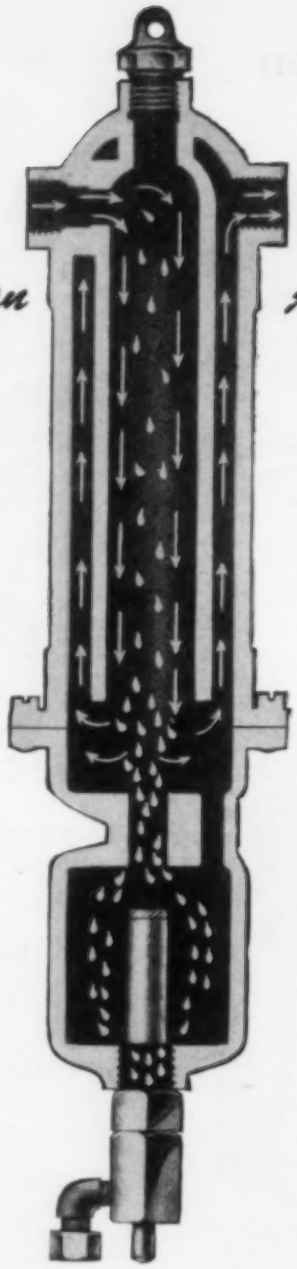
Anaconda Wire & Cable Co.

ANACONDA

Subsidiary of Anaconda Copper Mining Company
GENERAL OFFICES: 25 Broadway, New York City 4
CHICAGO OFFICE: 20 North Wacker Drive 6
Sales Offices in Principal Cities

Take this Air to the Dry Cleaners!

with the Swendeman Automatic Separator



The average compressed air line fairly reeks with moisture and oil droplets which no trap, valve or intermittent blow-off device can fully eliminate. Collecting in machines, literally spraying mist wherever the air stream goes, or mingling with paint to mar finished production, these two contaminators in your compressed air system can be saboteurs of the first rank.

Swendeman has the answer

Only the Swendeman Separator employs proved, automatic, result-getting principles to eliminate this menace to your production. Pressure and the flow of air remain constant, while precipitated moisture and oil particles are diverted by the Separator into an Eliminator which expels them immediately.

Because the Swendeman Automatic Separator is not a trap, it retains no oil or water within itself, and thus prevents them from re-entering the air stream once they are isolated from it. Venting to the atmosphere is continuous, insuring that the air cleaning process is one of maximum efficiency.

TYPE A

TYPE C

Used where pressure regulation is not necessary. Type A requires air shut-off while valve and screen are removed for cleaning. Type C has its own air shut-off.

A-3

Clean Dry Air is vital to:

Spraying **Sand Blasting**

Cleaning machines, cars, furs

Drying bottles, grain, cars

Operating machines, valves, switches and signal systems

Write for detailed literature.

The LEAVITT MACHINE COMPANY
ORANGE, MASSACHUSETTS

SWENDEMAN Automatic Air Separator
A DEXTER PRODUCT

improve your C.E.*

***CUTTING EFFICIENCY—**
the evaluation of work actually done by a chipping hammer

8-561

It pays off in dollars and cents to improve your C. E. Let us assume that a chipping hammer operator earns approximately $2100.00 per year. Since chipping hammers are used almost continuously by the operator, the cost of labor on a job goes down as the efficiency of the hammer goes up. Thus, in the course of a year, an increase in the overall C. E. of only 10% on one chipper means a saving of $210.00 in labor alone. This is equivalent to the original cost of 3½ new chipping hammers. Poor C. E. can be blamed on several factors: poor maintenance—low air pressure—improper tool selection—lack of suitable C. E. test procedure, etc.

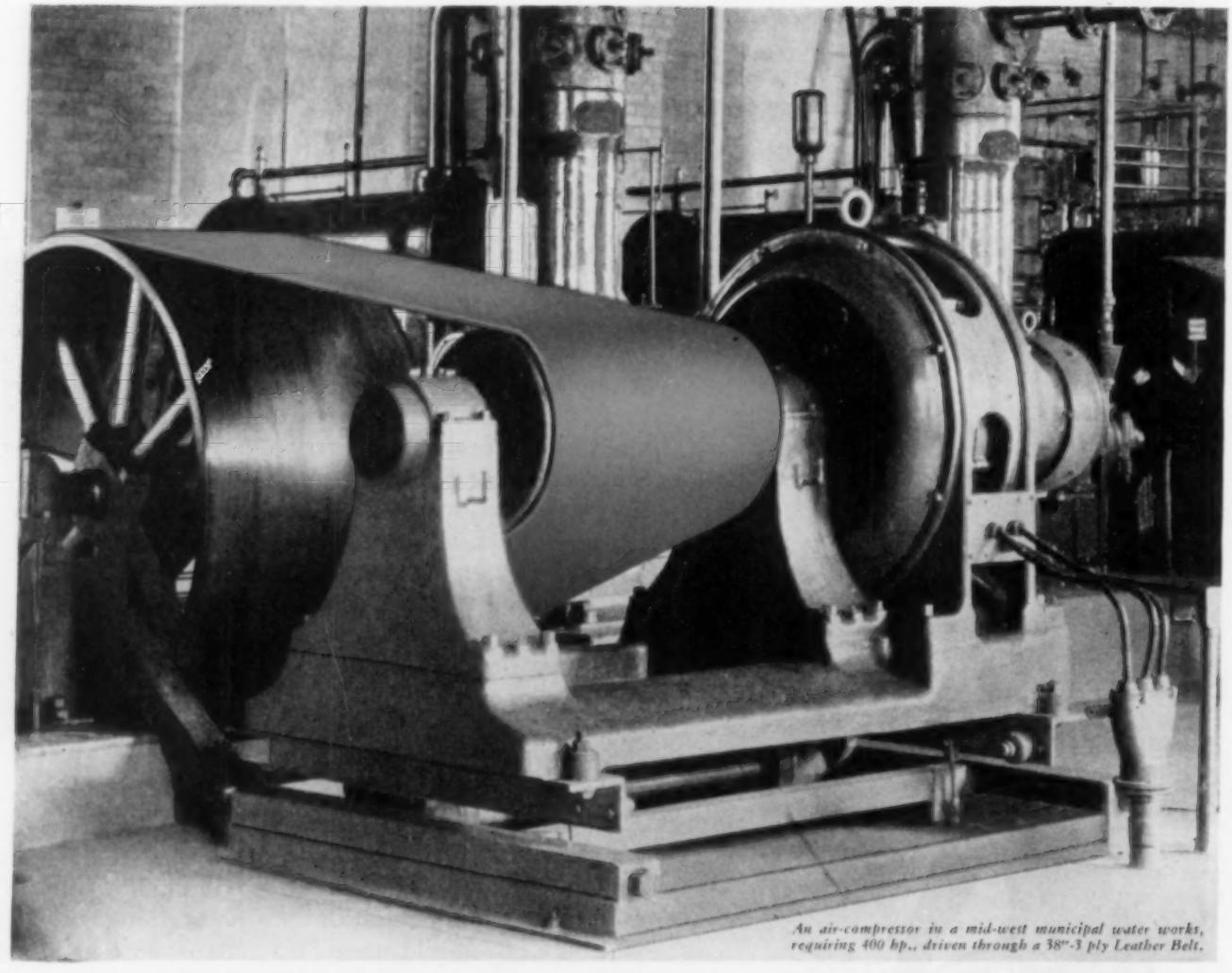
Whether you have one or one hundred chippers, our "cutting efficiency service" is available to you. An I-R service engineer will gladly call and make recommendations for maintaining the highest C. E. at all times. This includes instructions to repairmen for installing and repairing tools—setting up standard C. E. tests—checking air pressures, etc.

Send for a copy of our two-color Chipper Repair Chart, Form 5634.

Ingersoll-Rand
11 BROADWAY, NEW YORK 4, N. Y.

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

ONLY *Leather Belting* CAN DO THIS JOB PROPERLY



An air-compressor in a mid-west municipal water works, requiring 400 hp., driven through a 38"-3 ply Leather Belt.

"INDUSTRY LEARNS BEST FROM EXPERIENCE"

If you look in on many of the really "tough" jobs of Industry, you will find that Leather Belting rates high as a means of power transmission.

There are many good reasons why, but engineers whose job it is to see that the required power can be delivered to operating equipment, speak highly of its pulley-gripping characteristic that actually increases with increased load. They can count on Leather Belting to meet all load conditions.

This fact in itself reflects a real dependability which can be "standard" in War or Peace, in plants that rely on Leather Belting.

LEATHER BELTING IS EASY TO SELECT, INSTALL AND MAINTAIN, AND CARRIES THE LOAD!

AMERICAN LEATHER BELTING ASSOCIATION · 41 Park Row, NEW YORK 7, N. Y.

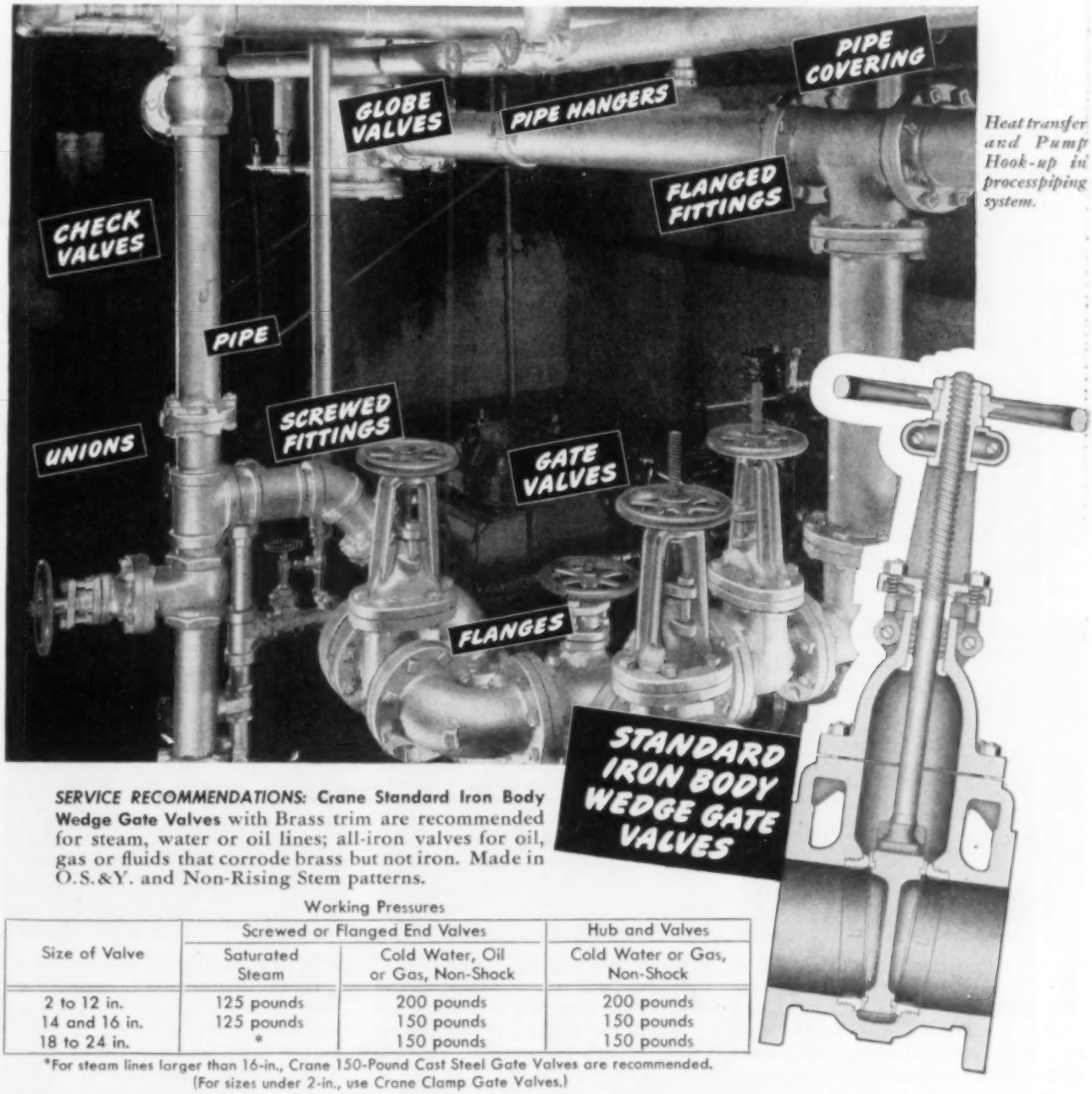
On All Your Piping Materials
. . . BE SURE WITH CRANE

ONE SOURCE OF SUPPLY

ONE RESPONSIBILITY FOR ALL PARTS

ONE STANDARD OF QUALITY

A single source—your Crane Branch or Wholesaler—supplies them all—valves, fittings, pipe, fabricated assemblies, piping accessories—for any service. One standard of quality for all parts, with a single responsibility behind them, helps assure the best installations. Deferred replacement work is speeded up and simplified. Not only do you choose from the world's greatest line of piping materials—*for example, in the Standard Iron Body Wedge Gate Valves shown below*—but you also benefit from 90 years' experience in meeting industry's piping requirements.



Heat transfer and Pump Hook-up in process piping system.

***SERVICE RECOMMENDATIONS:* Crane Standard Iron Body Wedge Gate Valves** with Brass trim are recommended for steam, water or oil lines; all-iron valves for oil, gas or fluids that corrode brass but not iron. Made in O.S.&Y. and Non-Rising Stem patterns.

Working Pressures

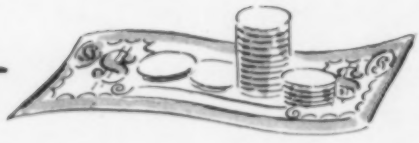
Size of Valve	Screwed or Flanged End Valves		Hub and Valves
	Saturated Steam	Cold Water, Oil or Gas, Non-Shock	Cold Water or Gas, Non-Shock
2 to 12 in.	125 pounds	200 pounds	200 pounds
14 and 16 in.	125 pounds	150 pounds	150 pounds
18 to 24 in.	*	150 pounds	150 pounds

*For steam lines larger than 16-in., Crane 150-Pound Cast Steel Gate Valves are recommended. (For sizes under 2-in., use Crane Clamp Gate Valves.)

CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill. *Branches and Wholesalers Serving All Industrial Areas*

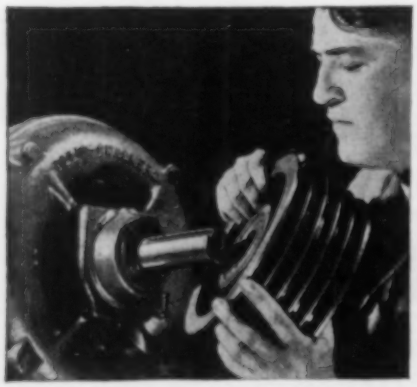
CRANE

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

Trade this for this ; save and 

No more *forcing* of sheaves. Simple wrench operates Allis-Chalmers' "Magic-Grip" — *fastest mounting and demounting sheave on the market.* Saves time, money.

SEE HOW QUICKLY, EASILY THIS NEW SHEAVE MOUNTS AND DEMOUNTS

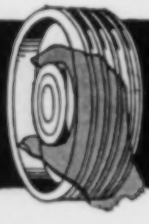


1 Place sheave on shaft. Slides on smoothly because clearance is provided by expanded bushing. There's *no* hammering — *no* forcing! Complete sheave and bushing unit comes intact—ready for quick, easy mounting.

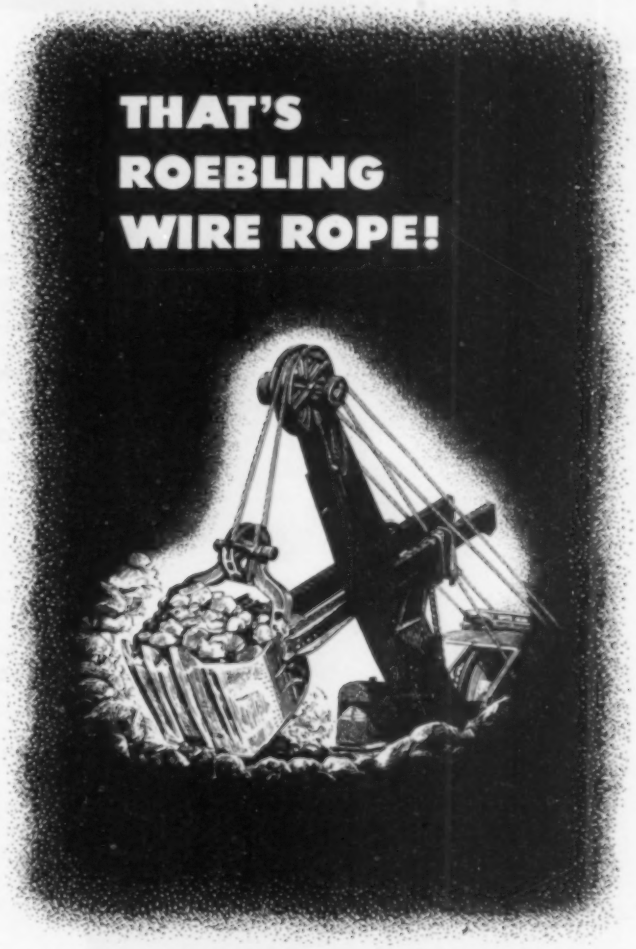
2 Slide to desired position. Sliding easily, sheave can be placed *exactly* according to straight-edge . . . giving you true alignment with resulting smooth performance. A minimum of time is required.

3 Tighten three capscrews — and it's ready to go! Entire sheave is locked securely to shaft and *grips like magic!* No set screws to damage shaft. Send for Bulletin B6310. Allis-Chalmers, Milwaukee 1, Wis.

A 1855

Allis-Chalmers Texrope "MAGIC-GRIP"  SHEAVES

Taking Heavy Strains in Stride...



AND WHERE'S THE CONSTRUCTION JOB that doesn't need tough lines on shovels and scrapers, hoists and draglines? Operating efficiency demands rope that can take extra heavy strains in stride . . . can stand up under sustained punishing service without faltering . . . Roebling "Blue Center" Wire Rope!

After all, the basis of good wire rope is the steel in the wires. Roebling "Blue Center" Steel—the finest wire rope steel produced—is custom-made in our *small* open-hearth furnaces, where quality is closely controlled. Add 104 years of experience in rope-making . . . unsurpassed facilities for research — testing —manufacturing . . . and *you* get the utmost in wire rope value.

Roebling engineers are at your service . . . to help you select the rope most suitable for your particular need . . . and get maximum service from it. Call or write our nearest branch office.

JOHN A. ROEBLING'S SONS COMPANY
TRENTON 2, NEW JERSEY
Branches and Warehouses in Principal Cities

WIRE ROPE AND STRAND • FITTINGS • SLINGS AERIAL WIRE ROPE SYSTEMS • SUSPENSION BRIDGES AND CABLES • COLD ROLLED STRIP • HIGH AND LOW CARBON ACID AND BASIC OPEN HEARTH STEELS • ROUND AND SHAPED WIRE • ELECTRICAL WIRES AND CABLES • WIRE CLOTH AND NETTING • AIRCORD, SWAGED TERMINALS AND ASSEMBLIES

ROEBLING

PACEMAKER IN WIRE PRODUCTS

Specify "NORTON RESINOID"

For Fast Cutting Action

Grinding wheels on portable grinders are not treated gently. They need abrasive grains that are strong and rugged as well as sharp. Laboratory control at the Norton electric furnace plant followed by special crushing and screening methods results in abrasives with the necessary chemical and physical characteristics. When used in a wheel of the proper grade (bond strength) for the job they combine fast cutting action with economical wheel life.

For Smooth Cutting Action

Constantly improved resinoid bond formulae developed by the Norton research laboratories are such that under the heat of grinding the bond softens just enough to act as lubricant. Loading is decreased and the wheels have a smooth grinding action. And the resinoid bond has just enough resiliency to make the wheels hug the work and prevent bouncing.

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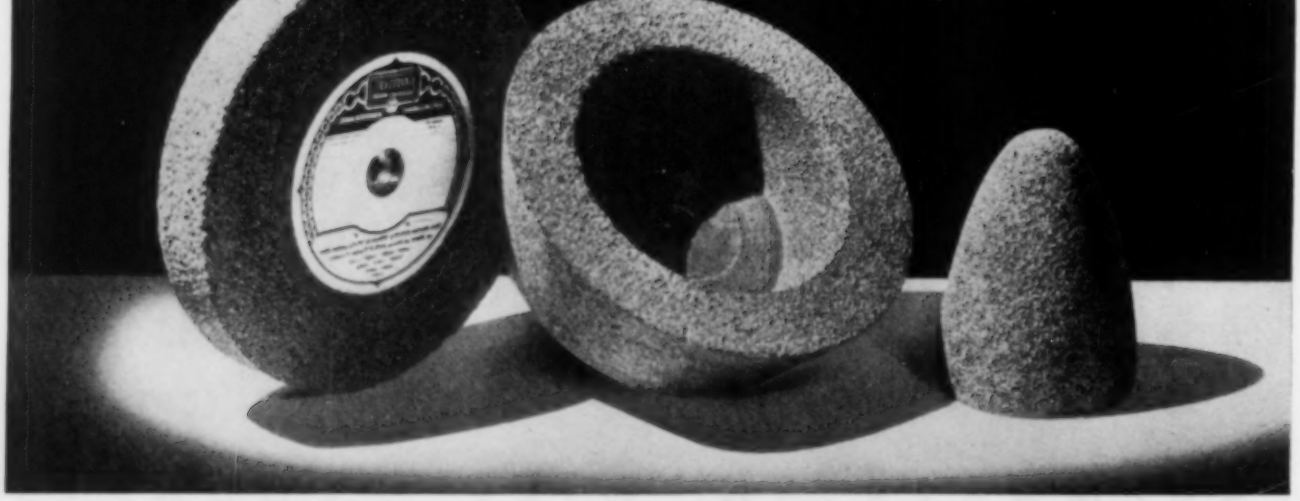

OUR COVER DESIGN

IN COMMON with other American publications we are devoting our June cover to furthering the success of the Seventh War Loan Drive. The cover features a special message to the American people from our seven 5-star generals and admirals.

Along with the letter is printed the official insigne of the drive, an artist's adaptation of Associated Press Cameraman Joe Rosenthal's epic photograph of the Marines hoisting the Stars and Stripes on the crest of Mount Suribachi in Iwo Jima last February 28. The price paid to make it possible to take the picture was 4100 American lives. Four of the men who helped raise the flag have since been killed in action.

We can add little to the appeal that our cover carries, other than to impress upon our readers the vital need for all of us to invest more money this time than we did in previous War Loan Drives.

•

IN THIS ISSUE

AMONG the almost miraculous accomplishments of American industry during the war, those of the airplane-manufacturing companies stand out in sharp relief. In point of dollar volume, the production of Curtiss-Wright Corporation gives the latter first rank in the field. Our leading article describes one phase of that concern's operations, the activities at its Buffalo plants.

•

FEAR of an impending petroleum shortage stirred up great promotional activity in American oil shales 25 years ago. The Government inaugurated experimental work on treatment processes, but abandoned it when the oil industry discovered new producing fields. Now history is repeating itself. Augmented by war's heavy drain on our petroleum resources, there is again talk of a shortage, although some high authorities say our reserves will suffice for at least another generation. Be that as it may, it is comforting to know that we have an ace in the hole in the form of our great western shale deposits. In the interest of national security, the Government is renewing its research to determine suitable mining, retorting, and refining procedures. The article *Oil Shales of the West* brings us up to date on the subject.

•

GROWING things without soil is simplicity itself, as is explained in the article *Gardens Without Soil* by M.R. Vogel. You merely make a solution of the chemical foodstuffs the plants require and feed it to them in the correct amounts. The author's interest in the subject is understandable, as he is both a chemist and an amateur gardener.

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Curtiss-Wright's Buffalo Plants

R. G. Skerrett

SINBAD the Sailor of the Arabian Nights was more than a spinner of amazing yarns. Indeed, his stories told centuries ago have proved him to have been virtually a seer. His fabulous Roc, the gigantic bird that could pick up elephants and fly away with them to feed its nestlings, seems no longer wonderful in our age of mechanical marvels. We are today building transport planes that are quite the equal of the Roc in weight-lifting, and far superior because of what they can do under the guidance of resourceful human pilots. Such are the accomplishments of the aeronautical engineer aided by his mechanical fellows and thousands and thousands of trained workers. How has this come to pass?

The question is answered in part by reports made public by our national legislators. Up to 1939, American airplane builders were mainly engaged in designing and constructing machines for commercial airlines. Their products were of the made-to-order types to meet the recurrent demands for bigger and better planes. At that time our aircraft industry was represented by a handful of medium-sized companies that had also been turning out a moderate number of fighting planes, largely experimental, for the Army and the Navy. But the Government was rudely awakened in 1939 to the facts that this nation was confronted with a grave emergency and that our fighting forces were ill equipped for aerial combat. Something had to be done with the least delay to give us aircraft capable of meeting our potential enemies.

This involved the enlargement of existing plants, the building of others of still greater size, and providing ways and means for increasing the output of subcontractors, of which there are many thousands today. It meant an abrupt transformation from custom-made practices to mass-production schedules—in short, a revolutionary change in procedure as well as in volume and speed of

PLANES AND THEIR PRODUCTION

An interior view of a C-46 landing-gear well, into which wheel and landing gear are retracted during flight, appears in the circle. The girls are inspectors. In the center are shown two C-46 Commandos, one camouflaged and the other unpainted, with a consequent saving of 100 pounds in weight. In the adjacent picture, left, are seen six P-40 fighter planes escorting a bomber on a flight to Guadalcanal. Underneath each P-40 is a detachable auxiliary gasoline tank to carry extra fuel. Commandos on the final assembly line at Buffalo are illustrated below. Mothers working in the plant may leave their children at the child-care center (opposite page) established by a group of women headed by Mrs. Burdette S. Wright, whose husband is a vice-president of the Curtiss-Wright Corporation.

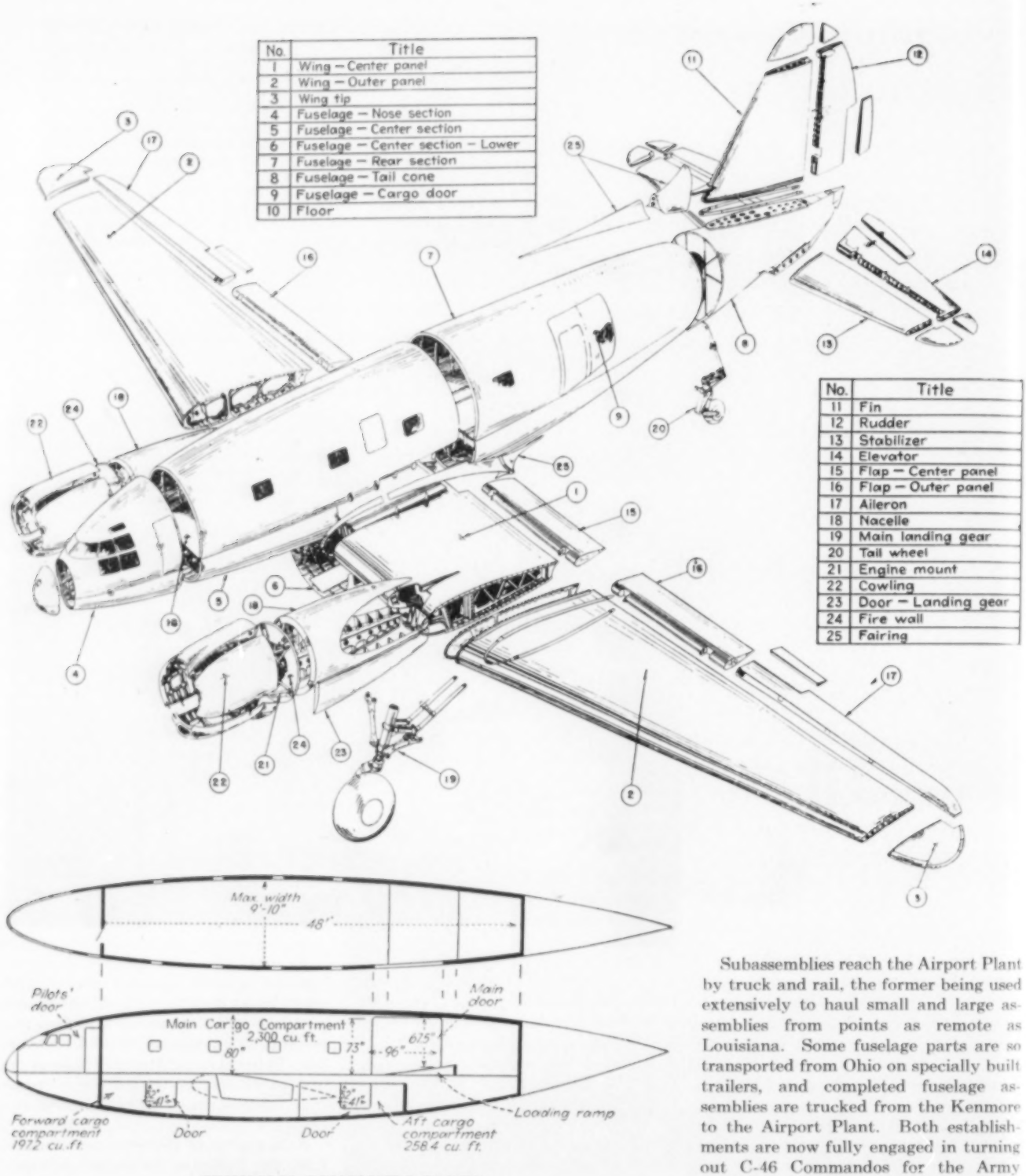
output. When that decisive moment arrived, the Government naturally turned to the foremost of the nation's airplane builders. The largest of its contracts was allotted to the Curtiss-Wright Corporation with its diversified lines of production carried on by three main divisions located in different parts of the country and engaged in turning out Curtiss airplanes, Wright engines, and Curtiss electric propellers. This brings us to the purpose of this article, which deals with the corporation's Buffalo, N. Y., plants where is to be found a striking demonstration of what trained minds, qualified supervision, and skillful hands can do in response to the needs of national security.

But first let us draw some facts regarding the Curtiss-Wright contracts from the third annual report of a U. S. Senate Committee. To quote: "In the period from June 1, 1940, through March 1, 1943, ... the corporation received war supply contracts in the amount of $4,717,500,000 . . . . . These contracts have since been increased" and "the Government has spent millions of dollars for the creation of new facilities." Recognition of competency on such a scale was flattering, but it also invited staggering difficulties. The concern had to continue operations with increased tempo at all its divisions; and at Buffalo, where it had a well-organized establishment, it had to construct and equip a far larger plant beyond the city limits.

There was the further problem of obtaining and training a big working force. The job was a complicated one. Mass production calls for the utmost care in tooling, as well as in designing and making jigs and other fixtures needed for the interrelated and repetitive operations by which multiples of many different parts are manufactured with precision to permit speedy assembling. The situation was made harder because Plant No. 2, generally known as Buffalo Airport Plant, had to produce more than one type of aircraft—pursuit planes and much larger transport planes. For some months now it has concentrated on the building of transports, C-46 Commandos. This was done after the corporation had concluded its contracts for Army P-40 fighters and for other kindred aircraft.

As a matter of contemporaneous history, the P-40 was the original airplane. Then modifications known as the Kittyhawk and Warhawk were produced by Curtiss-Wright. Before the P-40 attained general acceptance by the Army Air Forces, the type was sold to England as the Mohawk and Tomahawk; but beginning with the P-40N it was decided that all P-40's should be referred to as Warhawk. Therefore all these fighters, with the exception of their engines, were of the same general type.

Operations at the Airport Plant are carried on in close coöperation with the older Kenmore establishment situated several miles distant on the outskirts of



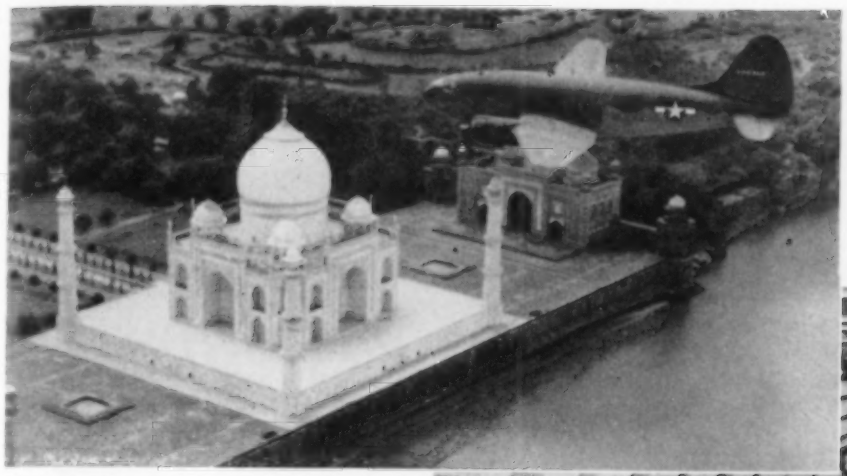
PRINCIPAL COMMANDO PARTS

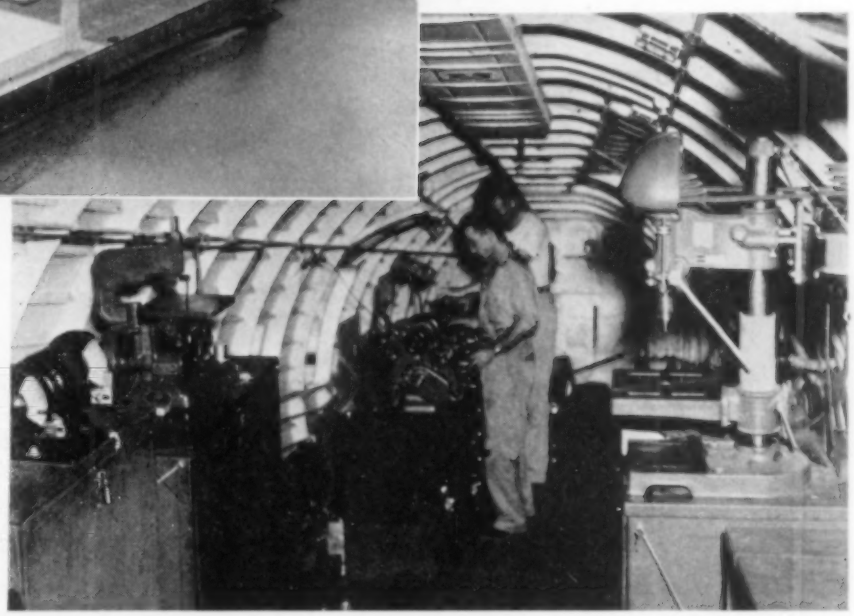
A major disassembly drawing of a C-46 and, at the bottom, plan and longitudinal sketches showing cargo spaces. Wide doors and a new type of ramp within the plane accelerate loading and unloading of motorized equipment.

Buffalo. Kenmore is engaged in subassembly work; at the Airport Plant planes are completely assembled and tested prior to acceptance. This great factory is adjacent to the Buffalo Municipal Airport which also serves Curtiss-Wright as flight-operation headquarters from which its ships are tested. It is the corporation's dominant establishment because it is the administrative center and the location of its research department, modification center where relatively moderate changes can be made in a finished plane, two subassembly divisions, an academic school, a capacious hangar, a flight hangar, and a ramp from which aircraft take off for testing and for delivery either in the United States or abroad, depending upon their tactical radius.

Subassemblies reach the Airport Plant by truck and rail, the former being used extensively to haul small and large assemblies from points as remote as Louisiana. Some fuselage parts are so transported from Ohio on specially built trailers, and completed fuselage assemblies are trucked from the Kenmore to the Airport Plant. Both establishments are now fully engaged in turning out C-46 Commandos for the Army and for the Air Transport Command, which serves the entire Army as well as other U. S. Government agencies and our Allies.

At both plants in Buffalo more than 40,000 people have been at work during periods of peak aircraft production, the number of women employees averaging 40 percent. The workers are drawn from many walks of life, most of them with no previous factory experience. Yet, under a system of careful selection and training, they are quickly taught to do the jobs assigned to them according to their aptitudes. Operations are usually





IN FOREIGN LANDS

The official Army Air Forces photograph reproduced at the left shows a C-46 Commando over the famous Taj Mahal at Agra in the China-Burma-India theater of war. Below is an interior view of a Commando-borne machine shop that is used in fighting areas to repair damaged planes that have been forced to land at locations remote from established bases.

on a 24-hour, 3-shift schedule six days a week; but when time is pressing they are carried along the full seven days. The atmosphere in the plants is that of orderly bustle and intent application. There is no confusion, and the discerning eye easily follows the sequence by which a plane evolves from parts to finished product by a process that is continuous and steady. It will not be possible to give more than the barest sketch of how this is accomplished.

In 1942 the Government called for an initial output of 50,000 aircraft a year, and within that period American companies turned out 48,000. In 1943 the total was 64,000, and last year we constructed 96,369 planes of all types. The chairman of the War Production Board announced before the close of 1944: "So far in this war, we have built 240,000 airplanes." This amazing record has been made despite many difficulties. A governmental report issued about a year ago disclosed some of the obstacles that have beset the industry. We are told that "Our airplanes are being subjected to constant modifications, in some instances several hundred modifications for a single type of plane. Some modifications are slight and not difficult to make, and some are of such major importance as almost to require the reconstruction of the plane. Some of the modifications are made at the aircraft plants. Others are made in modification centers under the direction of the Army and Navy and several industrial concerns. In some instances additional modifications are incorporated abroad before the planes are put in actual combat. The completion of such modifications sometimes requires many weeks.

"Sometimes the delivery of planes has been further delayed by the inability to obtain all the necessary instruments and equipment for use at particular fighting fronts, for which the planes are destined. For instance, planes have to be 'winterized' for use in cold climates and 'summerized' for use in hot climates." These circumstances tend to hamper production schedules, but that is inevitable when the instrumentalities for waging warfare are in a continual state of flux. A knowledge of these facts makes for a better grasp of the contribution Curtiss-Wright, among others, has made towards equipping our armed services.

From the latter organization we have the following explanation of what it did to minimize confusion and to save lost time. "Most of our early troubles, which were caused by numerous design and equipment changes requested by the Army Air Force, have been eliminated through the establishment of what we term 'the lot and block system.' Basically this method 'freezes' a plane model for a certain specified number, and all within that lot are identical. Then the next lot including recommended changes is frozen for production as soon as the changes, that may be both major and minor, have been decided upon. This method has been of great advantage in supplying replacement parts, which are so important in keeping aircraft in condition for service."

The Army's Warhawks were constructed in Buffalo until the latter part of 1944 and are still active on many fighting fronts where they are used variously as intercepters, fighters, bombers, and even as transports. Like the Curtiss SB2C Helldivers, which are serving the Navy in dive-bombing operations and are built at the corporation's Columbus, Ohio, plant, the P-40's are of comparatively moderate dimensions. Their wing span is approximately 37 feet, the over-all length of the fuselage is a trifle more than 33 feet, and the gross weight is around 9500 pounds. The engine is of 1125 hp. and is capable of giving the plane a maximum speed in excess of 350 miles an hour and of lifting it to an altitude or "ceiling" of 30,000 feet. The Warhawks are made up of more than 20,000 numbered parts, not to mention 100,000 other standard parts such as rivets, nuts and bolts, clamps, etc. The global service record of this basic type is a fine one, for they saved the day for us on many occasions when they alone were available to face punishment in some of the critical stages of the war.

While less spectacular, the C-46 transports are more notable as examples of aeronautical engineering and wide service in bolstering the battle fronts even though not actually fighting. Each of these great cargo planes is put together with more than 460,000 rivets, requires in excess of 2 miles of rolled-aluminum structural sections, has in it about 5 miles of electric and control wires, and embodies a proportionately larger number of parts and assemblies than the P-40. But don't let the number of parts mislead you into thinking that nice regard as to weight is less necessary in a Commando than in a Warhawk. Every

PNEUMATIC TOOLS

Literally thousands of air-operated tools are used in building aircraft, and special small, lightweight models have been developed to fit the varied needs. These pictures show several types of Ingersoll-Rand tools in service at the Buffalo plants. In the center, William Taylor, a skilled craftsman, is grinding a clamping "V" block that will become part of an extrusion fixture for use in producing plane parts. At the right, a woman employee is drilling 3/16-inch holes in a subassembly part. A similar tool, with a Drexler 90-degree attachment (lower right), enables the operator to drill in a hard-to-get-at place. The girl seen below is riveting the leading edge of a P-40 wing.

excess pound in one direction entails a sacrifice in another.

In the military plane, excess weight may enforce a reduction in ammunition or in fuel, cutting down its tactical range accordingly. In a Commando it curtails the flying radius through a reduction in fuel and may, to a certain extent, also lower the weight of the cargo that can be handled. In a commercial transport an excess of 1 pound in the structure may entail a revenue loss of more than $100 a year, or of $1150 to $2000 during its operating life of from 9½ to 10 years. The importance and the frequency of the service rendered determines the measure of the sacrifice; and while the hampering effect of excess structural weight in a Commando is not gauged on a money-loss basis, still it does levy a toll in some form of impaired efficiency. Hence the great nicety called for in designing such a craft and in following through by continual inspection everything that enters into its construction.

The term "air-frame" embraces the entire structural get-up of an airplane—the fuselage, wings, control surfaces, and the enveloping shell or skin. The engine or engines have to develop sufficient power to move, lift, and propel the fully laden craft at a prescribed maximum speed; and to obtain both lightness and strength the builder uses alloyed aluminum extensively and metals such as stainless steel, chrome-molybdenum steel, magnesium alloy, and certain bronzes to a lesser measure. The skin, known to the industry as Alclad, consists of an alloyed aluminum base on which has been rolled a thin sheet of pure aluminum. The bright surface is exposed to the outer air because it is more resistant to corrosion than the alloyed aluminum.

The internal members are mainly rolled and extruded sections that are bound together generally with bolts or rivets and interconnected where needed by bracing to give each part the necessary structural rigidity. This is understandable when we think of the great speed at which a big transport travels either with or against the wind, and the stresses that may be set up in the structure even under favorable conditions as the drive of the engines overcomes the resistance of the air. These stresses may be considerably augmented in rough weather, and the plane must therefore be put together so well that it cannot be torn apart by the winds. The craft has to be so streamlined that the reactions between it and the flow of the air will cause the air to sustain the plane's deadweight while inducing the least possible resistance and the development of "drag" on any of its exposed surfaces.

Air resistance aloft can be greatly lessened by the shape and smoothness of the exterior surfaces of a plane and by retracting its landing gear and other projecting members or working parts

that can be housed within its body after the take-off. In the case of the rivets which tie the Alclad sheathing of the wings and fuselage to the internal framing of a Commando, for example, the heads must not project more than 1/1000 inch above the surface, while the rivets in the nose section of the fuselage and the leading edge of the wings must not be sunk more than 2/1000 inch below the surface lest skin friction be induced and cause a drag that may add to the load on the engines and reduce the aircraft's speed. The remainder of the rivets on the C-46 are of the brazier-head type. Flush-rivets are used more extensively on high-speed fighters and bombers because they require that everything possible be done to reduce resistance to air flow. The maximum speed of the Commando is in excess of 250 miles an hour, a velocity at which brazier-head rivets in other than frontal areas do not cause sufficient drag to be of moment. It is because of skin resistance that combat planes are no longer given a camouflage coat of paint but shine with the silvery brightness of their Alclad sheathing. Omitting the paint results in some increase in speed and effects a saving in weight on large transports and bombers that approximates 100 pounds!

While security restrictions do not permit divulging further details about the P-40, we can tell more about the C-46. The general dimensions of the latter are: wing span, tip to tip, 108 feet; length of fuselage, 76 feet 4 inches; over-all height from floor-line level, 29 feet 8 inches; and over-all height from 3-point position, 21 feet 9 inches. Each is equipped with two Curtiss 4-bladed, full-feathering, electrically controlled propellers 13 feet 6 inches in diameter. These are driven by two Ford-built Pratt & Whitney R-2800 engines which are capable of spinning them at 2700 rpm. at top speed—the maximum point for which the governors are set. The operating speeds while in flight may be between 1500 and 2000 rpm., depending upon whether maximum endurance or efficiency be desired.

The engines can lift a Commando to an altitude of 10,000 feet in 13.5 minutes when its gross weight is 45,000 pounds. At that height its cruising speed is 227 miles an hour, and at 13,000 feet it can be driven 265 miles. The two motors permit the aircraft to reach a service ceiling of 24,500 feet; but under the propulsion of only one unit the ship has a service ceiling of 12,000 feet. In getting off the ground, the engines are powerful enough to give the plane sufficient impulse to rise and clear an obstruction 50 feet high after a run of less than 2700 feet.

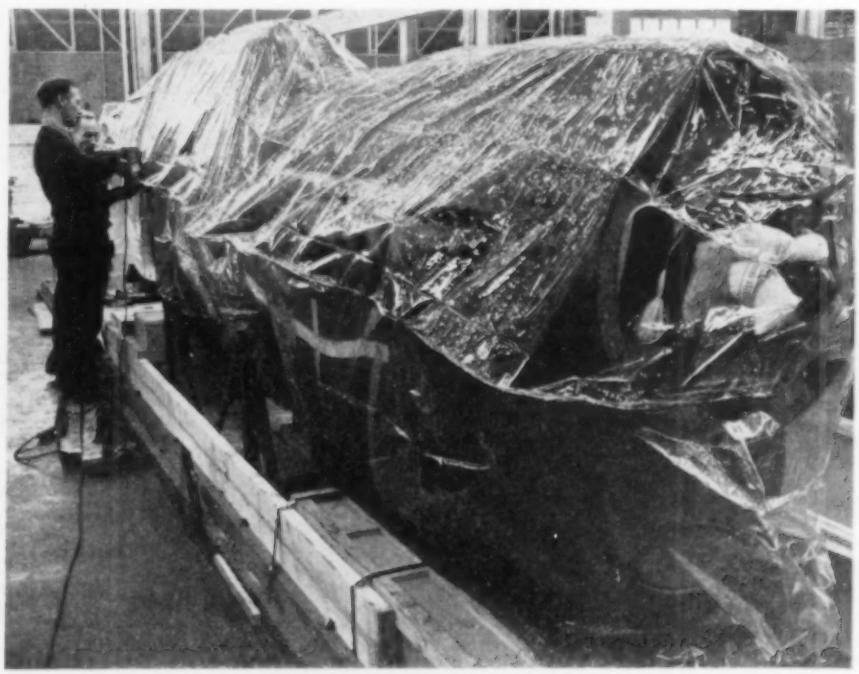
As the Commandos are designed for transport work, each has one large and two smaller cargo compartments with a combined capacity of 2755.6 cubic feet. The main compartment is in the upper section of the fuselage and is 48 feet long, 9 feet 10 inches wide, and 6 feet 8 inches high. The two lesser ones are forward and aft in the belly of the plane and have 197.2 and 258.4 cubic feet available. A cargo door aft in one side of the big compartment has a clearance lengthwise of 8 feet and a height of 5 feet 7.5 inches, which makes it possible to take large unit shipments. The floor or deck of the latter is so well supported that it will bear safely a concentrated load of about 435 pounds on a single transverse beam, or a uniform load from side to side of the floor of about 70 pounds per square foot.

General cargo is held in place by ropes or webbing straps secured to tie-down fittings spaced longitudinally in the deck and also in the side framing and ceiling. As a troop carrier, drop-down benches at the sides of the main cargo compartment will seat 40 men, with their equipment piled along the center of the floor; when moving sick and wounded, 33 hospital litters and two attendants can be accommodated. A C-46 can put enough gasoline in her fuel tanks housed in her wings to give her an operating range of 1800 miles.

According to a Government report: "The Commando is the largest two-engine transport and cargo plane which has been built, and is considered the best of the two-engine cargo planes because of its greater carrying capacity and range." It has been further stated officially: "Hundreds of thousands of tons of supplies have been moved by air to sustain military operations, which would otherwise have been absolutely impossible. Without these planes, we could not have taken or held Guadalcanal; we could not have sent thousands of American and Australian troops over the Owen Stanley Mountains to the north coast of New Guinea to force the Japanese from North Papua and northwestward along the coast to the outskirts of Salamaua. In short, we could not have prosecuted the campaigns which constituted our first great offensive against the Japanese.

"Similarly, cargo and transport planes were of tremendous value in supplying military operations in Burma, China, Russia, and North Africa and, indeed, everywhere that combat has taken place. Some high Chinese officials have stated that without the aid afforded by cargo and transport planes, China could not have continued an effective resistance to the enemy. Cargo and transport planes were also used in China and Burma to evacuate and save from capture by the Japanese hundreds of women and children and skilled personnel. In some cases, planes flew out of Burma with three times as many passengers as they were designed to carry. Thousands of wounded men have been evacuated by air to points of safety where they could obtain adequate medical attention. Many of them owe their lives to these planes, and many others were saved from amputations and disfigurement.

"A fourth great service of cargo planes



WRAPPING IT UP

A P-40 fuselage being packaged in Pliofilm for overseas shipment. Seams are heat-sealed, next the envelope is evacuated through a tube at one end, and then the tube is sealed. Bags of Protek-Sorb inside the container extract moisture from the remaining air and thus prevent corrosion of metal parts.

was the transportation to the United States of strategic materials that were urgently needed here to speed up essential war production that otherwise would have been reduced in volume and delayed for months. These are contributions to the winning of the war of the very highest order, and all who have participated in building and operating these planes and providing the necessary air fields and equipment to maintain them may well be proud."

Since the foregoing was made public, other facts about subsequent services of the Commandos have been given out, and of these performances none is more wonderful than the work done in connection with the "Hump" that had to be flown when the Japanese held sway in crucial sections of the Burma Road. It seems that weather conditions over that formidable mountain region are wellnigh indescribable and trying. On a single run, as many as ten or twelve violent thunderstorms may be encountered. Winds are met that often have a velocity of 100 miles an hour, with the movement being both vertical and horizontal, and to reach less tempestuous weather conditions pilots frequently have had to climb to altitudes exceeding 20,000 feet. But the heavily loaded Commandos, because of their strength and their superior flying characteristics, stood the test and are still weathering the storms and delivering their goods.

Probably one of the least known uses to which these "freight cars of the air" have been put is that of serving as flying repair shops. One such unit was assigned to the 20th Bomber Command based in India. This Curtiss C-46 had the job of salvaging a damaged B-29 Superfortress that had landed on her belly in the wilds of a mountainous section of China. The scene of the crash landing was 700 miles from the U. S. Army base, and within 24 hours after the relief craft arrived the bomber was repaired and able to get away under her own power. The equipment in the workshop in the main cargo compartment of that Commando included an air compressor, a drill press, a lathe, and such other machines and hand tools as were needed to install a new nose on the injured Superfortress. This is just one of the many things that have been done by these flying repair shops.

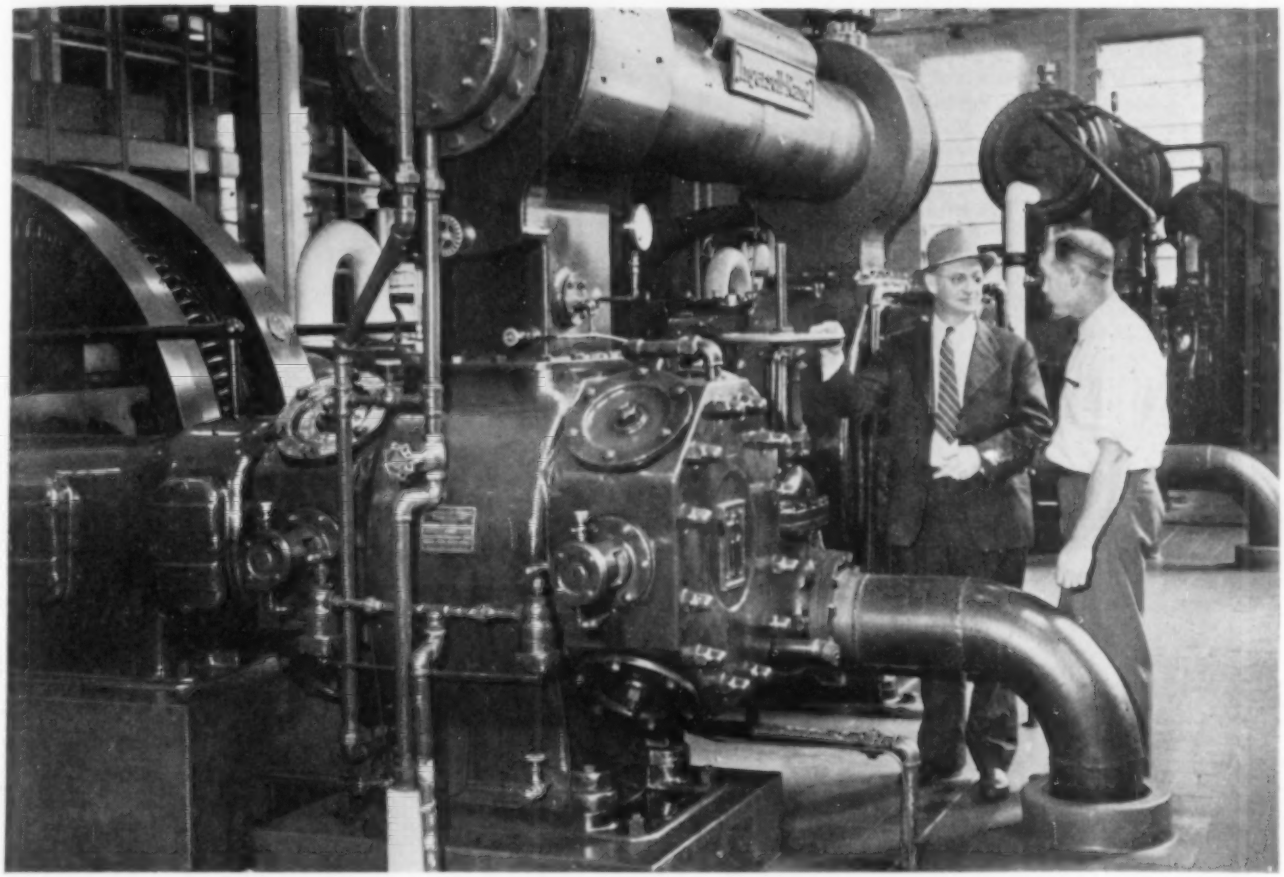
The first C-46 came into being nine years ago as the CW-20 and was the product of 36 months of intensive study. Initially, the type was designed as a commercial cargo carrier that would give maximum service at relatively low operating cost. When war was upon us, the CW-20 was modified by the Curtiss-Wright Corporation and became the C-46 to function as a military cargo and troop transport. Today, these dependable craft are carrying, apart from the things already mentioned, mail, gasoline, jeeps, tractors, trucks, field pieces, mules, and what not.

It is not possible here to enumerate the varied facilities that are in the two Curtiss-Wright plants in Buffalo. There are many different kinds and sizes of pneumatic tools, air-operated machinery, and functional aids. Metal parts are formed by presses that range from those exerting a squeeze of 3000 tons to machines that have to apply the relatively low pressure required to bend to exact curvature the small brass pipes that constitute the arterial system by which hydraulic mechanisms do many essential things at points remote from the controls within ready reach of the pilot. There are miles of overhead runways that are used only to transport tote pans and parts which can be lifted manually. The conveyor carriers are approximately 5 feet long, and the system supplants the usual machine-shop traveling cranes. Bulky subassemblies are trucked through the plant; and assembled sections are mounted on "V" casters that ride on inverted angle irons forming tracks that differ in width with the application. The placing of each identical structural assembly is so precise that corresponding openings of a dozen or more hull sections appear as a single smooth passageway. As far as practicable, workers are

Official Photo Army Air Forces

A TOKEN FOR TOJO

Lieutenant McClung climbs into the cockpit of a P-40 fighter plane that has been pressed into service as a bomber. Somewhere over Burma he dropped his single bomb on which was chalked, "You can't beat U. S." The plane's decorations were inspired by those used by the Flying Tigers, American volunteer airmen who flew for China before we got our air forces organized. The P-40 has a speed of more than 350 miles an hour.



AIR COMPRESSORS

Three Ingersoll-Rand, 30-inch-stroke, steam-driven machines and one 21-inch-stroke electric unit supply air for diversified purposes in the Airport Plant. Shown standing by the electric-driven machine are Guy Maher, power-plant chief (left), and Stanley Tredinnick, chief steam engineer. There is an identical group of compressors in the nearby Kenmore Plant. Supplemental units of smaller capacity are located in different parts of the factories.

grouped agreeably to their tasks; and it is said that speed of output depends upon doing everything as completely as it can be at an early stage in construction.

The jobs range from light to heavy ones; and women show special aptitude where the work calls more for skill than strength such as making minor fittings and turning out small weldings. They are also likely to excel at repetitive tasks that involve accuracy and perhaps that degree of monotonous perfection associated with aircraft building and adherence to minute weight tolerances. To get women of suitable qualifications, Curtiss-Wright does everything it can to make working conditions pleasant as well as possible. For mothers with small children the corporation has established a child-care center where the kiddies are looked after while the mothers help to build airplanes.

At both the Kenmore and Airport plants are well-equipped hospitals administered by competent staffs. In advance of assignment, each worker is given a physical examination and, so far as it can be done, a medical record is obtained. If any physical defect is discovered, the person is not employed at any job that might impair his or her efficiency or invite injury while on duty. Of course, the primary purpose of the medical department is to prevent production losses through time out due to accident, illness, or disease.

As work goes on 24 hours a day, the inner man must be cared for, and at the Airport Plant there are two cafeterias. Serving begins at 11 a.m. with the factory workers and proceeds at half-hour intervals until 12.30 p.m. Following this there are three 20-minute periods for the office, clerical, and engineering employees, so that the complete luncheon program is over by 1.40 p.m. Dietitians are responsible for the daily change in menu, and ample good food is provided virtually at cost. One of the cafeterias serves 26,000 hot meals daily; and the kitchen bakes 1100 pies each day.

The up-to-date power plants in the two construction centers are equipped with modern boilers fired with powdered coal which is pulverized just before it is blown into the furnaces under forced draft. This is particularly needful at the Airport Plant which has no tall chimney to invite trouble for craft from the nearby airport. In each powerhouse are four large compressors that range in capacity from 1055 to 3026 cfm., with a discharge pressure varying from 80 to 110 pounds. In addition, there are many other stationary compressors of considerably smaller capacities in different parts of the plants, as well as some high-pressure portables that are used in connection with planes just before they start from the airport on a flight.

The importance of compressed air at the Buffalo plants is evidenced by the total output which, if all the machines were operating at the same time, would amount to more than 20,000 cfm. The need of all this motive air is due to the fact that it is required not only in the shops but also in the research division, the modification center, the school, the subassembly division, and the nearby Pennsylvania Central Airlines airport that is used by Curtiss-Wright.

No one can now foresee how great will be the demand for military airplanes in years to come, but it is reasonably certain that commercial airlines in their peacetime operations will need increasingly larger numbers of transports. The Commandos, by reason of their magnificent performances in the years of war, have furnished the Curtiss-Wright Corporation with a wealth of information that will be invaluable when the world returns to normal or, at least, more nearly normal conditions.

TYPICAL OIL-SHALE LANDS

Views in the Uinta Basin of Colorado and Utah, showing oil shales as revealed by erosion. The strata are nearly horizontal and the oil-shale beds are generally the darker bands. They are covered with overburden ranging in thickness from a few feet to several hundred feet. The region has a semiarid climate and there is usually little vegetation. In places the topography borders on typical "badlands."

Oil Shales of the West

James O. Ball*

THE intense interest and activity in oil shale by individuals, business concerns, educational institutions, and the Government have not been generated by promotional schemes but by the course of natural events. Since 1938 consumption of petroleum in the United States has exceeded the amount discovered, and of late years the difference has widened. The decline is not due to lessened activity on the part of those in search for new sources of supply but to the fact that no large bodies of petroleum have been found.

Our reserves of petroleum, as estimated by the American Petroleum Institute in April, 1944, were 20.4 billion barrels. Prewar production was at the annual rate of 1.5 billion barrels, and today's output is estimated at 1.8 billion. Ten years hence, if we calculate the rate of production on the basis of present reserves, there will be a shortage of 500 million to one billion barrels.[1] The deficiency will depend upon whether prewar or present rates of consumption are maintained; and as time goes on, output will decrease. These figures show that it will be necessary to provide at least 1.5 billion barrels of oil per year if we are to continue the American way of life and that, unless discoveries exceed consumption, the difference will have to be made up from imports of petroleum or from synthetic oils produced from shale, coal, or other sources of hydrocarbons.

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The United States has a substantial interest, through various companies, in the enormous reserves of petroleum found recently in Arabia, Iraq, Venezuela, and other foreign countries; and from all indications we intend to use those resources. Our largest oil-consuming section is the eastern seaboard, and with the prevailing low transportation rates over water, synthetic fuels from the western part of the United States will have to compete with importations from abroad if the laws of economics are allowed to take their natural course.

There is another factor, however, which cannot be overlooked, and that is our national security. Our future economy will not be secure if it is dependent upon foreign sources of oil, for we have not reached the stage where reliance for keeping us out of conflicts can be placed upon our statesmen with any degree of assurance or confidence. This factor alone should exert considerable influence upon the necessity of supplying ourselves with adequate fuel from within our own borders. The production of sufficient quantities of synthetic fuels, together with our present reserves of crude oil and those yet to be found, will go a long way towards promoting and maintaining security provided, however, that costs are kept low through research and technological developments.

OIL shales constitute an important reserve of oil, and there are great deposits of them distributed widely throughout the world. The most notable occurrences are in Scotland, France, Manchuria, Estonia, Australia, Canada, and the United States.

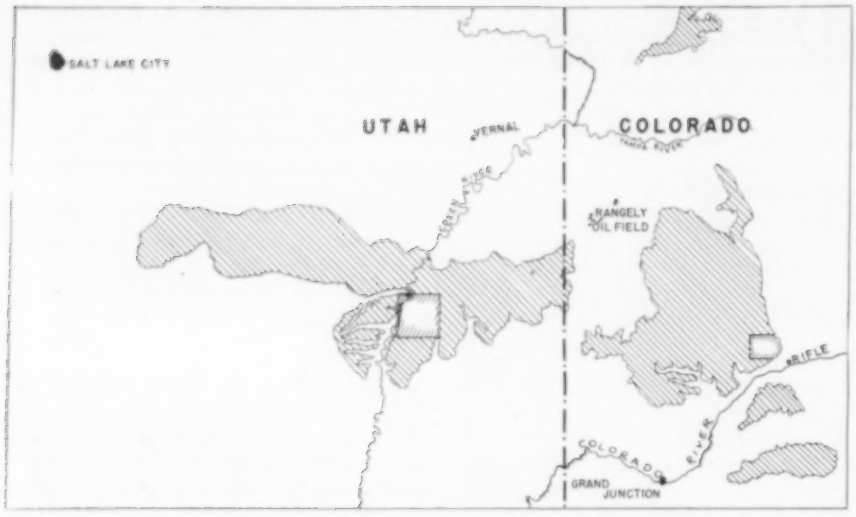
Our discussion of the resources is confined to this country, particularly to the region known as the Uinta Basin that is situated in the Rocky Mountains where Colorado and Wyoming adjoin the eastern boundary of Utah. By far the largest shale deposits in the United States are in that area.

Since this article was written, Harold L. Ickes, Secretary of the Interior, has announced that $1,500,000 has been allowed for the construction of an experimental plant at Rifle, Colo. This includes a camp for workmen, an experimental mine, and units for retorting the shale. Equipment for refining the oil will be installed later.

In view of the facts just emphasized—namely, that discoveries of sources of crude oil in this country have been slowing down and have not been equal to demands, that there is danger of our known reserves becoming depleted because of enormous consumption, and that foreign sources of crude oil, however plentiful, might not always be available—it is obvious that serious attention should be given to the technology and methods of making liquid fuels from our immense domestic reserves of shale and coal.

Concerned over future supplies of liquid fuels, Congress, after extensive hearings by a subcommittee of the Senate on public lands, enacted Public Law 290 on April 5, 1944. This approval by Congress and the President provides for a major research program by the U. S. Bureau of Mines looking primarily towards the development of alternate sources of liquid fuels. It will include both laboratory and pilot-plant work which should culminate in demonstration plants of a minimum size that will, eventually, allow the Government to furnish the necessary funds and engineering data for the establishment of a synthetic-liquid-fuel industry. Contrary to widespread impression, neither the act nor the Bureau of Mines contemplates the building of large standby plants, the commercial operation of a plant of any size, or the construction of even demonstration units until laboratory and pilot-plant research has been carried out.

The law authorizes the expenditure of $30,000,000 over a 5-year period. As originally introduced, the bill covered oil shale and coal, but friends of agriculture brought in farm and forestry products. As a result, the law emerged with the provision that the latter phase of the work should be done in coöperation with the Department of Agriculture.



DISTRIBUTION OF WESTERN OIL SHALES

The shaded areas indicate the locations of deposits that may yield 75 billion barrels of oil. Rifle, Colo., where the Government's new experimental plant will be built, is shown. Federal reserves are indicated by squares. The remaining lands are mostly owned or controlled by the nation's large oil companies.

With an initial appropriation of $5,000,000, the synthetic-fuels program calls for three demonstration plants: one for the extraction of oil from shale, another for the conversion of coal and agricultural products into liquid fuels by direct hydrogenation, and the third for the same purpose but utilizing the gas-synthesis process.

The Bureau of Mines[2] has announced that a new oil-shale section has been set up within its Petroleum and Natural Gas Division and has started planning the research and development laboratory. This is to cost about $450,000, and is to be established on the campus of the University of Wyoming at Laramie. The bureau also has announced that surveys are now being made with a view to selecting a demonstration-plant site in the Green River shale district in Colorado-Utah. The preliminary work is being conducted between Rifle and De Beque in the Piceance Creek Basin, an area that is largely government owned and includes naval oil-shale reserves numbers 1 and 3. Headquarters for the survey have been established at Rifle, Colo. It was near here that considerable research was carried on by the Bureau of Mines during the 1920's.

The work done in the past may be classified under the following headings: Reserves, mining, retorting, and analysis. Virtually nothing has been done in connection with refining the shale oil and the spent shale for the recovery of by-products.

Reserves

The possible reserves of shale oil in the three states of Colorado, Utah, and Wyoming have been estimated by Winchester[3] of the U. S. Geological Survey at 131 billion barrels, with a possible recovery of 75 billion barrels from the retorts—47.6 billion barrels from Colorado; 25.6 billion from Utah; and 1.8 billion from Wyoming. In arriving at these figures, oil shales less than 1 foot thick and yields of less then 3000 barrels per acre, or 15 gallons per ton, were not considered. The recoverable oil was based upon 60 percent of the total estimated reserves.

Colorado shales lie mainly in nearly horizontal beds between strong shale roof and floor rock. Some of these are known to be more than 500 feet thick, with an average oil content of 16 gallons to the ton. Deposits exceeding 100 feet in thickness yield 25 gallons, and some of 18 feet, 47 gallons. The oil content was determined mostly by sampling the face of the exposed shale beds. However, many shallow test holes also were sunk throughout the area for that purpose. Very little core drilling has been done, and it seems advisable before undertaking any large-scale operations to do considerable coring and assaying to establish accurately the quality and the extent of the deposits.

Mining

The problem of mining shale in large quantities is yet to be solved. What experimental work has been done indicates that the material will not be difficult to drill and blast. As to the mining method—whether room-and-pillar, caving, or open pit, that will depend upon the location of the operation with respect to the retorts, the thickness of the shale bed, and the magnitude of the project.

The costs of working deposits of varying thicknesses and oil content by the first two methods have been estimated by Gardner and Bell[4] and are given in an accompanying table. They include interest and amortization charges. In areas where power shovels can be employed in open pits, shale beds 500 feet thick and containing about 16 gallons per ton can be mined at an approximated outlay of as little as 21 cents per ton when handling 5000 to 8000 tons per day. Based on the aforementioned table, the estimated mining cost of a barrel of oil (42 gallons) by caving and open pit would be 95 and 55 cents, respectively. However, those that are well acquainted with the oil-shale country state that the percentage of the reserves that can be worked by the latter method is very small.

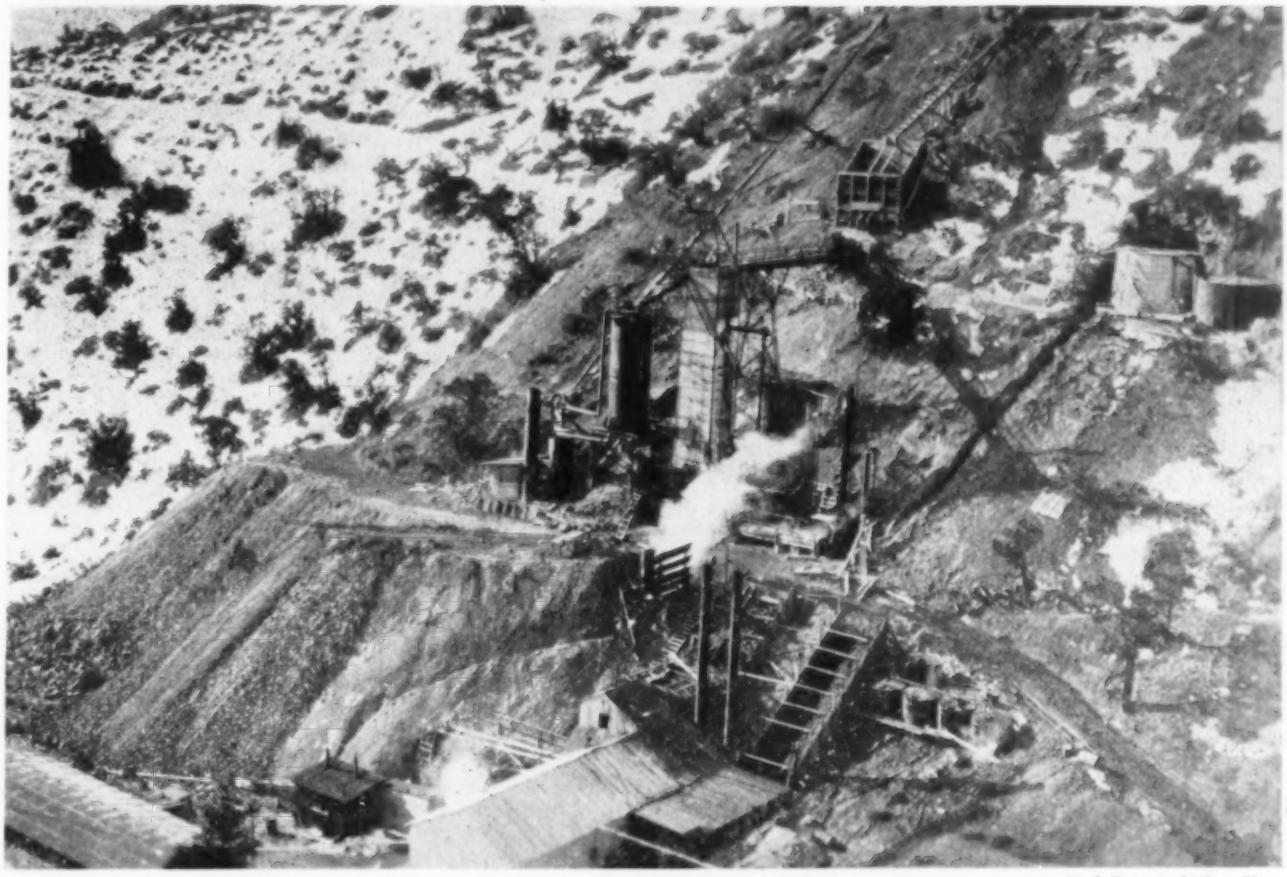
Retorting

There is perhaps no venture in which so much money and effort have been spent with less results than in that of retorting oil shale. A number of the schemes were the outcome of honest application, and others were just promotional. Most of them seem to be the ideas of mechanics rather than of those capable of applying scientific knowledge. To date, no commercial oil-shale process has been developed in this country, although many retorts have been proposed and a few patented. These may be classified under the continuous and the batch type, externally and internally fired. Very little is known about the performances of the externally fired continuous retort. In the United States the trend is towards the latter type and work is now being done on a number of such units.

Considerable data are available on externally and internally fired batch retorts. From 1925 to 1927 the Bureau of Mines operated two such units at Rulison, Colo.—a Pumpherston (Scottish) retort fired externally from the bottom, and an N.T.U. fired internally from the top. Large-scale tests were made and showed that 89.3 percent of the assayed oil value was recovered in the case of the former and 96.7 percent in the latter.

ESTIMATED MINING COSTS

Method	Thickness of Shale (Feet)	Grade of Shale (Gallons per Ton)	Shale Mined per Day (Tons)	Cost of Mining Shale (per Ton)
Room and Pillar.....	20	44.3	2,000	$1.004
Room and Pillar.....	20	44.3	4,000	0.964
Room and Pillar.....	44	35.4	5,000	0.712
Caving	106	23.8	10,000	0.538



U. S. Bureau of Mines Photo

FORMER EXPERIMENTAL PLANT

From 1925 to 1927 the U. S. Bureau of Mines intermittently operated at Rulison, Colo., the retorting plant shown here. It consisted of two units, a Pumpherston retort and an N.T.U. retort. The latter recovered 96.7 percent of the assayed oil content of the shales and the former 89.3 percent. The dump at the left is spent shale.

The bureau has recently announced that the N.T.U. type has been adopted as a standard of comparison for use in judging the performances of other retorts.

Analysis

The shale from which oil is extracted is a brownish-black, hard, rock-like substance about twice as heavy as water. The oil obtained does not exist as such, but is derived from a component called kerogen. This material is of organic origin and is made up principally of carbon, hydrogen, oxygen, nitrogen, and sulphur. The molecules are considered to be high in molecular weight. They are soluble in ordinary organic solvents to the extent of 2.5 percent. However, when heated to a temperature of approximately 800°F. they are decomposed to form compounds of simpler and smaller molecules. The oil is dark-greenish in color and is similar to petroleum. When distilled it yields the range of hydrocarbon products usually obtained from petroleum, plus a few that are derived from coal tar. When cracked to supply a maximum of motor fuels, yields of 64 percent have been obtained.

The list of products readily obtained from shale is numerous and embraces gases—dry (including producer), saturated, unsaturated, and liquefied—gasoline, naphtha, kerosene, gas oil, waxes, lubricating oils, fuel oils, road oils, spray oils, phenols, pyridine and other nitrogen compounds, asphaltic materials, ammonia, and ammonium sulphate. Quantities are not given for the reason that the products will not be the same for all retorts—will vary as much in shale oil as in petroleum. A number of the substances are not stable in that they change color when exposed for a considerable length of time to the atmosphere or sunlight. This indicates that they are unsaturated and are combining or reacting with impurities such as oxygen, sulphur, etc., to form heavier and darker products.

The unsaturated hydrocarbons should not be looked upon as undesirable, but as materials from which more valuable products may be made by means of hydrogenation, polymerization, or some other process now being used in the petroleum refining industry. Spent shale has been suggested as a source of by-products such as cement, among others. Up to the present, however, none of a definite character has been obtained. The reason for this is the lack of knowledge about the composition of shale. When this is definitely established, more will probably be forthcoming.

Cost of Production

The cost of producing a barrel of shale oil will include mining and crushing charges, as well as those for retorting the shale, refining the oil, and disposing of the spent shale. The final cost should include taxes, depreciation, overhead, etc., but these items will not be taken into consideration here. A study of the table on page 158 shows that mining charges decrease as tonnage increases. A plant retorting 10,000 tons of shale a day could not, in view of our present oil consumption, be classified as anything more than a pilot plant. A unit of this capacity would be ideal for obtaining data and the "know how." To produce 100,000 barrels of oil a day would require 100,000 to 200,000 tons of shale, or 2500 to 5000 freight cars. Mining operations of this magnitude are scarce. With increasing activity, the costs should decline to a level somewhat lower than those previously given.

Crushing or grinding charges will have to be included in the cost of producing shale oil because any economical retorting process will undoubtedly necessitate the use of shale in small particles. No

trouble is encountered in reducing the material to ¼- or ⅛-inch pieces, the gyratory type of crusher having been found to be very effective for all classes of shale, especially for that known as mahogany, which is the richest in oil content. Pulverizing is somewhat more difficult in large-scale operations, particularly with rich shale, as the fine material tends to gum. Basing reduction costs upon those pertaining to ores is apt to be misleading because some kinds of shale are very tough and resilient and do not crush as readily as ores. For example, while some of the latter can be reduced to ⅛ or ¼ inch at the rate of ten cents per ton, crushing shale to pieces of the same size will probably cost from 50 to 100 percent more.

Retorting charges should prove to be the lowest of the operational expenditures, because enough gas is obtained along with the shale oil to do all the necessary heating. It is unlikely that retorting will be done solely for the production of oil. However, even though there is every indication that the retorting costs will be low, it does not follow that the construction costs of the retorting units will be on the same scale. Plants that can supply oil in quantities, such as are processed today by many of our large petroleum refineries, will have to be equipped for high-speed retorting if building costs are to be low.

Very little is known about the refining of oil from western shales and about the products the oil will yield. All shales have different mineral contents. Once these are recognized, appropriate methods will be forthcoming. It is believed, however, that the products will cost more than those obtained from the average petroleum or will, perhaps, come close to the cost of those derived from petroleum high in sulphur and salt content.

Disposal of the spent shale has received some attention. This should not be much of a problem, because there is ample room in which to dump the material. After a period of operations, it could be returned to the excavations from which it came. The expense involved in this work should not be more than half of the mining cost.

Recent cold tests on shale oils produced by the various processes show that they are solid at 60°F. If the oil is to be pumped to distant points by pipe lines, heaters will have to be installed at intervals, or the lines will have to be buried sufficiently deep to maintain a temperature above the pour point. By another method, the marketable products will be separated from the shale-oil vapor as it leaves the retorts, after which they will be refined. The latter seems to offer greater promise of low-cost products than any of the others.

It is apparent from the foregoing that any attempt to figure out production costs is an uncertain proposition. However, to discuss this phase of the subject without summarizing it is unsatisfactory, so we venture, in conclusion, to estimate the cost of producing a barrel of oil from average shale in large-scale operations, as follows:

Mining 2 tons of shale	$0.70
Crushing 2 tons of shale	0.30
Disposing of spent shale	0.35
Retorting, based upon skimming a barrel of petroleum,	0.40
Total cost	$1.75

General administration expense, depreciation, and taxes are not included in the cost figures.

Within the next five years the research and technological investigations now in progress should have advanced far enough to give us answers to many of the problems now confronting the shale-oil program.

1. Mines Magazine, September, 1944.
2. Mining Yearbook, 1945. Colorado Mining Association.
3. U. S. Bureau of Mines Bulletin 23, 528, 1943. Kramer, A. J.
4. U. S. Bureau of Mines Information Circular 7, 218, 1943.

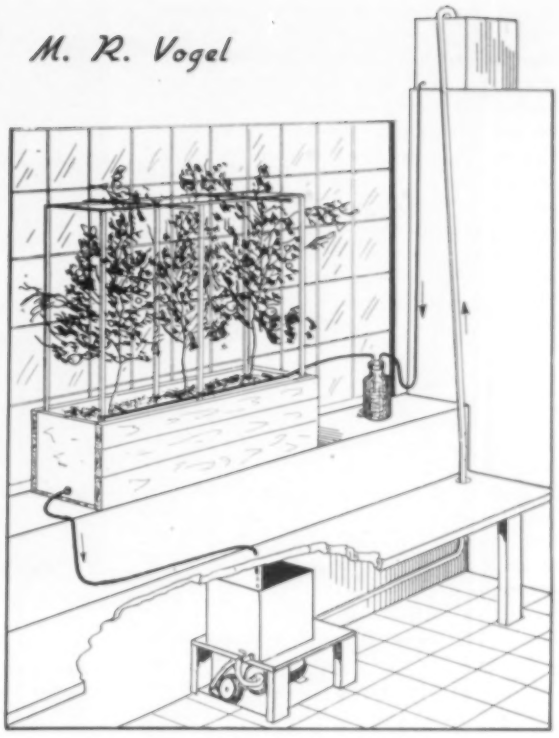
U. S. Bureau of Mines Photo

SHALE-OIL PLANT AT PUMPHERSTON, SCOTLAND

Scotland pioneered the processing of oil shale. The first extraction of oil was done in 1694, and commercial operations were commenced in 1853. During the next twelve years 65 plants were built. The workable shales are located just south of the Firth of Forth. Their oil content formerly ranged from 25 to 45 barrels per ton, but the richer grades have been so depleted that the present range is from 18 to 25 barrels. After trying out various types of retorts between 1865 and 1875 the industry developed a vertical, continuous-acting unit known as the Pumpherston which, in improved form, is still used. Scotland's oil-shale reserves are estimated at from 480 to 884 million tons, but mining and other operations are expensive. Since 1923 the industry has been subsidized as a defense measure. Six plants are reported to be operating and to be processing about 5000 tons of shale daily.

Gardens Without Soil

M. R. Vogel



TOMATOES ALL WINTER

Three tomato plants growing in a tank of cinders and, right, a sketch of the equipment used. Drainage collects in an 8-gallon sump and is pumped back once daily to an overhead reservoir with an old beer pump and garden hose. Feed and drainage lines are small rubber tubing. Three drip outlets are of glass. Glass wool in the bottle filters out solid materials.

IN THE year 1699 an Englishman named Woodward grew spearmint in water from various sources, and his experiments are generally considered to be the first attempts to cultivate plants without soil. In the following centuries others continued the study, and it remained for the Frenchman Boussignault to use chemical solutions of known compositions to raise plants in sand and sugar charcoal. Thus, in 1840, the fundamentals of controlled soilless gardening were first demonstrated. Knop and Sachs, in the 1860's, were the first to grow plants successfully by merely suspending the roots in jugs of chemical solutions, and their formulas are still used occasionally.

The amount of work done in this field increased steadily, although observations and information were more or less restricted to the scientific literature of the times. No one man discovered all the chemical elements required for normal growth, but the accumulated data indicate that the following are indispensable: Nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, iron, boron, manganese, copper, zinc, and probably molybdenum. In 1937, Dr. W.F. Gericke of the University of California drew the attention of a curious public to the commercial possibilities of this method of raising plants and coined the word "Hydroponics" (from the Greek stems *hydro*, water, and *ponos*, labor). Unfortunately, his suggestions were misunderstood, and the potentialities of this new kind of plant culture were greatly exaggerated.

Striking as the disclosures were to people who had always thought of plant and soil as inalienable, we are firmly told that no plant has ever done anything in a nutrient solution that it could not do in soil under proper conditions. Actually, the roots can absorb only such minerals in the soil as are dissolved in water and, with this fact in mind, the whole phenomenon is not at all sensational. Let us not assume, however, that the undertaking is a useless stunt, because it has played an important role in the study of plant life and will continue to do so. Practically all the modern laboratory work on plant nutrition has been conducted with plants growing in clean sand and fed with solutions containing predetermined and accurately measured quantities of various pure chemicals. The advantages of such control are obvious when one compares the simplicity of a chemical solution with the complexity of any soil.

Ever since man has cultivated plants for his own use he has known that they would thrive better in some plots than in others. There were always small differences in color, shape and size of leaves, stems, roots, flowers, and fruits which were often caused by chemical deficiencies or excesses in the soil solution in which the plants lived. Scientists have concerned themselves with just which and how much of each chemical element produced the various results.

Nature, of course, does not assume that a plant will always find ideal conditions; most plants are very adaptable and will yield something even when the roots must feed in a decidedly unbalanced soil solution. The goal of the research worker is to find out which combination will produce the best results with any given plant. Noteworthy progress has already been made, the fertilizer recommendations for many kinds of plants and soils suggested by our state universities and agricultural schools being but a small part of the contributions to everyday useful knowledge.

Other developments have centered around more direct applications of soilless gardening. A few florists have found it profitable to grow flowers in gravel beds fed with a nutrient solution because it is a distinct advantage to have such good control over the roots' environments. Soil, even when carefully prepared and treated, might turn up a fungus, an insect, or become chemically incompatible and threaten an entire crop. Laborious disinfecting or replanting must then be resorted to, and the outcome is often far from satisfactory. Gravel beds, on the other hand, are much easier to handle, for conditions can be readily corrected by draining, flushing, and refilling. Another feature is the possibility of changing the composition of the solution as plants develop. As seedlings, they can use certain chemical combinations to good effect, while a different combination will boost production at the flowering stage. The ease with which root beds can be kept from getting too sour or too sweet (pH control) also can be readily appreciated.

More recently the National Government has sponsored the training of military personnel in the soilless tech-

nique for very interesting purposes. There are some places in the Pacific area that do not have enough ground to produce any kind of worthwhile crop, and soilless gardening obviously is the answer to the problem of growing fresh vegetables. This sort of cultivation on barren islands has been going on with excellent results for a number of years, and the new program indicates that it is successful enough to be of military importance. We also hear of localities where the earth, though plentiful and fertile, is infected with soil-borne diseases and where chemical-gardening specialists move in to raise good things to eat for our wounded and convalescent soldiers.

The average gardener, of course, has neither the desire nor the means to convert his back yard by the installation of a system of tanks and piping, but it is not difficult to carry out a small-scale experiment. A 1- or 2-quart crock with a hole in the bottom and provision for catching drainage is the essential equipment for cultivating a plant of average size. Well-washed sand or fine cinders will serve as the growing medium, but care must be exercised not to introduce harmful chemicals or molds. The former can be washed out with water, and sterilization can be effected by baking in an oven for an hour. The nutrient solution can be bought in concentrated form at almost any store handling gardeners' supplies. It is diluted in accordance with directions, poured over the root bed, and allowed to drain through. This step is repeated daily, the absorbed and evaporated water being replaced as necessary. The total quantity of liquid in circulation should be about three or four times that held by the root bed when thoroughly wet and can be determined by experiment, always bearing in mind that there is danger of overconcentration of chemicals if the amount is not at least twice as large as that absorbed or evaporated in one day.

Should the experimenter desire to make his own solutions, he will find many formulas published in his state's agricultural-station bulletins. A simple one contained in Conners & Tiedjens book *Chemical Gardening for the Amateur* is given in an accompanying table. The salts should be dissolved one at a time, and any cloudiness that appears can be disregarded. It is recommended that technical- or fertilizer-grade chemicals be used because they usually contain, as impurities, sufficient quantities of the elements needed only in traces; namely, iron, boron, copper, zinc, and manganese. If the main chemicals are too pure, a special trace-element-solution formula (from the same book) can be made up as follows:

Manganese Sulfate	1.0	gram
Boric Acid	1.5	"
Copper Sulfate	0.5	"
Zinc Sulfate	0.5	"
Water	1.0	quart

One tablespoonful of this solution per gallon of nutrient solution should be used. Iron must be added separately because it precipitates out of solution so easily. A mixture of 1 gram of ferrous sulphate and 6 ounces of water will keep fairly well, and a tablespoonful of it per gallon of nutrient solution will suffice. The simplest procedure is to make up the required amount of nutrient solution, add the trace-element and iron solutions, and then immediately pour the mixture through the root bed.

WHITE GLOXINIA

The picture was taken about a month before the blooming stage. Two years ago, a dark purple variety was grown successfully in the same pot and nine flowers were open at one time. The simple double-pot arrangement used is illustrated at the right. The lower receptacle is watertight and contains the nutrient solution. The upper one is an ordinary flower pot filled with coarse sand and fitted with a glass-wool wick that passes down through the bottom hole. When this pot is in position, the wick extends into the nutrient solution and draws it up. The wick is divided at the top and branches horizontally in opposite directions to distribute the fluid adequately.

A satisfactory plant to try in soilless culture is the tomato. It is very responsive to proper nourishment, and the writer has grown good-tasting, meaty fruit for several successive winters in a tank measuring 9x42x11 inches. The unit is fed from three drips connected to an 8-gallon reservoir that is located about 6 feet above the root bed. Drainage is collected in an 8-gallon sump from which it is pumped back into the reservoir once a day. A system of this type requires a minimum of attention and is patterned after the methods used by commercial growers.

The fruit is unusual in appearance, being very bright in color, of smooth skin, and free of blemishes. Cucumbers, lettuce, endive, and carrots likewise were produced with good results. Celery, for some reason, turned out stringy and rather flat to the palate, but there is little doubt that it, too, could be raised successfully. Flowers, of course, can also be grown, and the writer has been particularly fortunate with gloxinias, which require a slightly different set-up. It consists of an ordinary clay pot filled with sand and provided with a glass-wool wick which extends down through the drainage hole. This is placed in another watertight pot which holds the solution. Experienced gardeners will find this arrangement particularly well suited to seed starting.

There are some rules, however, that

NUTRIENT SOLUTION

Superphosphate 44 percent	6.0	grams	or 1.5	teaspoons	
Nitrate of Soda	4.0	"	" 1.0	"	
Sulfate of Magnesium (Epsom Salts)	6.0	"	" 1.5	"	
Muriate of Potash	4.5	"	" 1.0	"	
Sulfate of Ammonia	2.0	"	" 0.5	"	
Water	5.0	gallons			

must be respected, because all higher-order plants, in soil or in prepared chemical solutions, will thrive only if certain conditions are maintained. The following precautions are listed with the tomato in mind, although they are applicable to all plants excepting where pollenization and fruiting enter into the raising of flowers.

The particular type of tomato selected for soilless gardening is of some importance, and tall-growing or late-bearing species should be avoided. A very large plant will require much room and considerable staking. The late-bearing varieties unnecessarily delay the climax and increase the chances of failure through possible accident. For the past two years the writer has grown the "Victor" tomato, an early determinate type capable of giving a good yield.

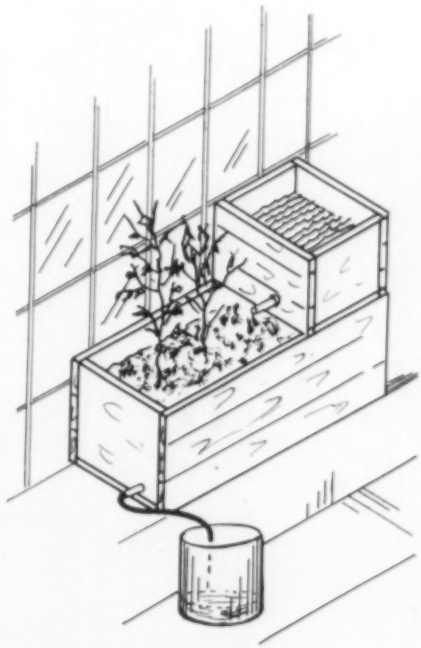
Proper amount of light is essential, and if the experiment is to be carried out indoors only a southern window will give about the minimum amount required. It is odd that many people had the idea that hydroponics would provide everything a plant needs. No substitute for light, of course, has been discovered, although artificial light can be used to supplement daylight or, if it is intense enough, even to do the whole job. Ultraviolet light is not essential, in fact can be detrimental in overdoses. In the wintertime it is desirable to capture all the daylight possible, even going so far as to use a white background during the shortest days.

The temperature of the immediately surrounding air should be lower at night than in the daytime for a very interesting reason. Starch and sugar are manufactured by a plant during the day, and they are the building materials for all parts of the plant. Normally, some of them are stored in the stems and elsewhere to be drawn upon when flowers, fruits, and seeds are being produced. But when night temperatures are too high, then starch and sugar are consumed in making more stems and leaves, little or no storage takes place, and the usual result is a big plant without flower or fruit.

The root system requires a certain amount of air because it cannot function properly if oxygen is excluded for days at a time. By the drained-crock or wick system, aeration is automatically maintained, but trouble can occur if the sand or cinders are too fine. Where the roots are suspended directly in the solution, the air is introduced by bubbling or splashing, much in the same way as oxygen is provided for goldfish. Some experimenters have gone so far as to suspend the lower parts of a plant in air in a closed box and sprayed solution on the roots. A container of that sort, fitted with a door, offers a very convenient means of studying the root system.

The atmosphere around a plant must not be too dry because the drier the air the more water the plant will send out to the leaves where it is respired, and a plant cannot be expected to do much of anything else if it has to expend a lot of energy evaporating water. Good humidity conditions are difficult to maintain indoors during the winter months, and a minimum of 25 percent relative humidity is almost essential. Holding the air temperature down is helpful, and open pans of water near the plant will contribute some moisture. A continuous room temperature of 75-85°F., with the relative humidity no higher than it is in the average home, will practically insure failure. It is also necessary to guard against gas poisoning, for traces of illuminating or furnace gas will stunt or kill most plants, and the tomato is especially sensitive.

Assume that a plant has been carried along to the point where blossoms have developed and that it is growing indoors. Under these circumstances we must assist pollenization, a job that insects do for us outdoors. Although self-pollenating varieties are to be had, it is generally more satisfactory to lend nature a helping hand at this point. It can readily be done with a soft brush, but there is a more interesting way that involves the use of certain chemicals in the plant-hormone class that are known to fertilize many blossoms. What is more, the subsequent fruits are seedless!



A SIMPLE SET-UP

Essentially all that is needed here are two wooden boxes lined with some watertight material, a length of tubing, and a can or bucket to catch the drainage. When the sump is full, it is lifted up and poured back into the reservoir at the right. An almost identical apparatus may be purchased in many stores handling gardening materials.

These chemicals can be purchased at seed stores, and very dilute solutions are applied by an ordinary atomizer.

Tomato blossoms are very responsive to artificial pollenization, and the extra flesh and juice obtained make it desirable. There is no cause for disappointment if a few come through with seeds, because accidents will happen even in the best of regulated plants. Sometimes many of the early blossoms will dry up before any fruit has set, but this is a common occurrence with all tomatoes. Once the green fruit begins to grow it is important that the roots never be permitted to become dry because that is what often causes blossom-end rot. Apparently, the thirsty leaves and stems draw water from the fruits, resulting in cellular breakdown.

It is a little difficult to tell without the aid of chemical tests just when the nutrient solution should be changed, but once a month will usually suffice. When such changes are made, the root bed should be flushed with water at room temperature before the new solution is added. Very cold water is to be avoided because the sudden chill can have a retarding effect, as anyone who grows plants in the house knows only too well.

Maintaining the proper pH may cause some trouble if a few simple precautions are not taken. The easiest way to test a solution is with pH papers, which are obtainable from any chemical supply house. Since the most common type of drift in the solution will be towards the alkaline side, it is necessary to provide a means of acidifying. A 5 percent solution of sulphuric acid will do very nicely, and the adjustment is made to a point just slightly acid (about pH 6). Should the solution become too sour while making an adjustment, or for any other reason, a small amount of lime water or dilute ammonia water will bring it back. In some localities, where the water is extremely hard, some acid will be needed in freshly prepared solutions.

The addition of Vitamin B_1 to the nutrient solution has been a controversial subject for some time, and most evidence to date indicates that it is of little or no value. Some experimenters, however, might want to try it, and for them it should be mentioned that a commonly used solution is one containing 1 part Vitamin B_1 to 10,000,000 parts water. The freshly prepared mixture should be poured over the root bed at once, because Vitamin B_1 in solution deteriorates rather rapidly.

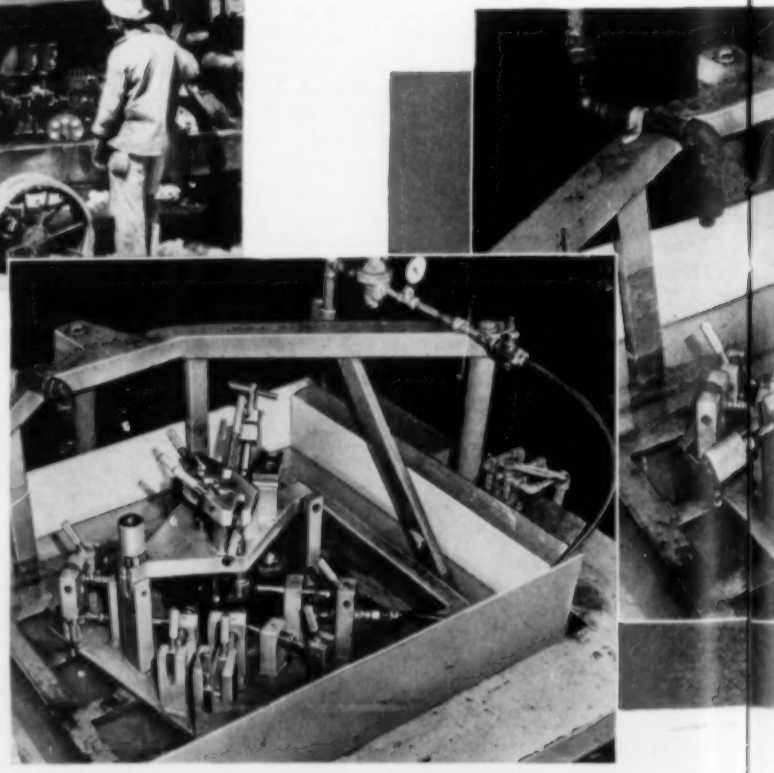
Anyone who takes up chemical gardening as a hobby will surely learn a great deal about the wonders of plant life. There is genuine satisfaction in overcoming the obstacles that are bound to arise, culminating in a sense of real achievement when the seedling has finally grown into a plant bearing fruits or flowers.

TWO banyan trees in the picture below form a frame for a coral quarry cleared in the jungle on Guam Island by Army aviation engineers. The coral was drilled, blasted, and loaded out at the rate of 2000 cubic yards a day. The product was heated to dry it, mixed with asphalt, and then applied as a surfacing material for runways and taxiways at Guam's North Field, a new B-29 base. Technician Fifth Grade James E. Seidel of Redrock, Tex., is shown in front of two air-cooled portable compressors that supplied air for operating rock drills.

Wide World Photo

Compressed Air

AT THE Telling-Belle Vernon Dairy in Cleveland, Ohio, milk bottles are rinsed at the rate of 180 a minute in the machine shown above. After being well soaked in a sterilizing solution, the bottles are placed on the revolving drum of the machine, fifteen to a row. Each row is washed for five seconds, after which the drum turns so that the clean bottles can be removed and the following row brought automatically into position for washing. City water is used and its pressure is increased to 85 pounds by the introduction of compressed air. The water is directed in the form of numerous jets against both the inside and outside surfaces of the bottles by suitable nozzles.

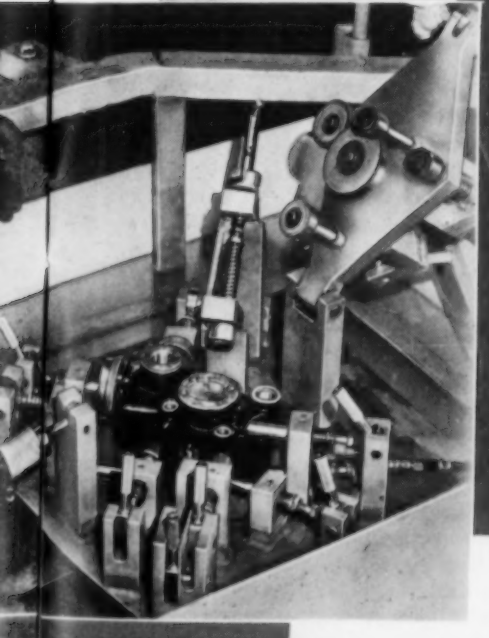


THE fixture at the right was developed at Bendix, Ill., to test complex airplane-carburetor castings for leakage by sealing all openings and applying air pressure internally while they are immersed, one at a time, in alcohol. When a casting is locked in position by swinging down the hinged cover, top openings are sealed by quick-acting cams that advance plungers provided with rubber gaskets. Similar plungers then close all side openings except one, to which an air line is connected. The whole assembly rests on a grid above the liquid level so that the operator's hands are not immersed. The grid is suspended from three vertical, air-operated plungers that lower the fixture and casting. The fixture makes for rapid operation without the necessity of heavy lifting. The pictures show it closed and open.

Institute Photo

A HELMET supplied with compressed air (right) protects an employee at Grand Coulee Dam, Washington State, from fumes as he applies hot tar enamel to abraded areas of a huge needle valve. The latter is being installed in a powerhouse of this largest of the world's dams to help carry off excess water while spillway work is underway on the Columbia River. The hose that supplies the compressed air may be seen draped over the man's knee. The needle valve weighs 70 tons and has a discharge capacity of 4000 cubic feet a second.

COMPRESSED AIR AT WORK



Wings Magazine Photos

THIS is an experimental pneumatic airplane tire that was built by the Goodyear Tire & Rubber Company and is reported to be the largest and heaviest yet produced. It is 110 inches in over-all diameter, 44 inches across the beads, and 36 inches from one sidewall to the other. The tire, tube, and rim assembly weighs 2600 pounds, the tube alone accounting for 250 pounds. For comparison, E. J. Thomas, Goodyear president, is holding a standard 6.00x16 popular-size automobile tire in front of the giant.

Rock-Drill Recollections

Jeffrey Schweitzer

SOUTH JACKSON MINE

Pictures taken soon after shaft sinking was started and when it was nearing completion. In the lower one, the hoist-and-compressor house appears at the right. Underneath it is an old boiler that served as an air receiver.

AIR drills of today are so efficient and easily handled that those who use them may not realize with what difficulties men of 30-odd years ago had to contend. Even at that time great progress already had been made in improving and altering the earlier models, and one would hardly have recognized the first Rands and Sargeants as the forerunners of such a machine as the then modern B-104. But possibly the greatest change of all that was being introduced around that time was the change from the "piston" to the "hammer" drill.

For several years prior to 1912, hammer drills had been utilized successfully for drilling uppers in mine stopes and raises and had just about displaced piston machines for such work. The latter, however, were still being used for all other operations. In the spring of 1912 the South Jackson Mining Company decided to sink a shaft on its property, the location being a mile south of the city of Jackson, Amador County, Calif. By early June the surface plant was nearing completion and preliminary preparations for the sinking of the shaft were being made. The shaft was to be vertical, to measure 7x17 feet outside timber, and to have three compartments, two for hoisting and the third to serve as a manway, for pipes, etc. The timbering was to consist of 12x12-inch sets placed 5 feet from center to center and lagged tightly by 2x12-inch planks.

Without giving it much thought, I had assumed that the drill to be used for sinking would be the Ingersoll-Rand C-110, then a new model. Mentioning this to the late Adam G. Huberty, the mine foreman, he suggested, to my astonishment, a new style of which he had heard recently—a hand-hammer sinking drill. Both of us readily agreed that such a machine would effect a great saving in time by eliminating the need of setting up and knocking down, as is required in the case of the piston drill; and if there were no other advantage, that one alone would be well worth while. Naturally, we had the example of the stoper drill before us, and we visualized for the hand sinker something of the same superiority that the stoper had shown over the piston drill.

Huberty and I arranged a meeting with the company's consulting engineer, the late James E. Davis (then superintendent of the Central Eureka Mining Company), so as to lay the matter of the hand-hammer sinking drill before him. He viewed the idea with favor, and the plan decided upon was to request the makers of hand-hammer sinkers to submit, at their own risk, one drill apiece for test. Whichever machine we should judge to be satisfactory, we would buy; the others we would return to the manufacturers at their expense.

Three concerns consented to our proposals, and in due course drills of "A" Company and "B" Company were received. Within an hour from the time the contest was started, Drill "A" had fallen to pieces and was eliminated. Drill "B" proved to be much too light, and its drilling power was almost nil. It, too, was worthless to us. So far the demonstration was discouraging. A BC-26 arrived from Company "C" a day later, and the following morning its test was begun. It was run all that morning and "walked" into the ground so that by noon all present were convinced that it would do. So I went into town to telegraph that friend of ours, H. L. Terwilliger, now as then head of Ingersoll-Rand's San Francisco office, that Ingersoll-Rand had won the competition and to send us two more BC-26's by express. Two of the machines were to be kept in active use, the third was to be available in case one of the others broke down, a needless precaution as it developed.

But when I returned to the mine after sending the telegram, what a change had occurred! Our troubles had begun! Every man on the job who could be spared was in or around the blacksmith shop working on the hollow steel used with the drill. It seems that soon after I left, one steel after another had become plugged until just about every piece was in that condition.

All kinds of suggestions for cleaning out the holes were offered. Heating the steel and cooling it suddenly had no effect, and long steel rods to run down through the hollow core proved useless. I was so upset that I was ready to quit hammer drills and turn back to pistons; but in spite of the discouraging situation Huberty still favored them and was confident that a solution for the plugged steel would be found. Huberty advised against any hasty action, and he was right. By the next day our capable blacksmith, George Nichols, had worked out a method, and it was as effective as it was simple. It consisted in holding the drill in a vertical position after filling the hollow core with water, raising it as high as he could reach, and then bringing it down with great force against an iron plate, thereby sluicing out the plug. That worry was over.

When working with a piston machine,

down holes were filled with water to eliminate the dust. Not so with the BC-26, because the air introduced into the bottom of the hole through the hollow steel formed bubbles in the water, and those bubbles were filled with dust. When they left the drill hole they burst, scattering the dust. If the blower was stopped for only a few minutes, the dust at the bottom of the shaft became so thick that it looked like a dense fog.

We were able to remedy this nuisance only to a limited extent by placing canvas pads over the tops of the drill holes and running the steel through the pads. The dust-laden bubbles rising in the holes broke against the water-soaked pads, so that a considerable percentage of the dust was caught. That helped, but unfortunately enough got away to cause annoyance throughout the entire time of sinking. That problem was eliminated a few years later by passing water through the hollow steel.

The BC-26 was supposed to have been handled by one man who was to hold the drill and turn it at the same time. The theory was fine, but in practice it was not so simple. If the reader does not remember, it should be explained that the machine was not equipped for automatic rotation of the steel. The miner twisted the drill alternately right and left through about a third of a revolution by the aid of a rotation handle attached to the side of the machine. It was found to be next to impossible for one man to operate a drill effectively. So two were assigned to each machine, one bearing down on the swivel handle at the top while the other turned. And if they did not coöperate, or if one got the idea that the other was not doing his share, trouble resulted.

It is interesting to recall that the steel was hexagon and sharpened, as recommended by the manufacturer, to a rose (6-pointed) bit. This was a difficult bit to sharpen, and it took plenty of time. Later, simpler and more easily sharpened bits were devised. And now the detachable bit—that is progress!

But our greatest trouble was drill-steel breakage. The steel was liable to snap at any point along its length, and on several occasions one piece broke at two places at the same time. When the shaft was completed, the pile of discarded steel behind the blacksmith shop was the size of a small hill. The most annoying circumstance of all was when, with only an inch or two of the last hole of a round to be finished, the steel broke in such a manner that the hole had to be entirely redrilled, thus causing considerable delay. This happened many times.

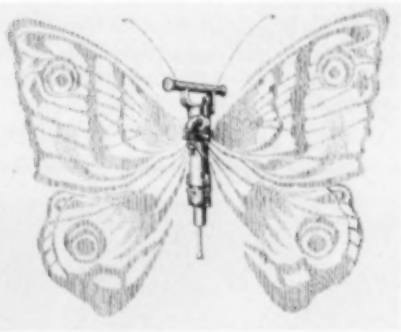
The cost of drill steel was high, being 99 cents per foot of shaft sunk, or 2.5 percent of the cost ($39.60 a foot) of the shaft. That total low cost was due to several favorable circumstances and to a bonus paid to the miners for additional footage; but the BC-26's, aside from the difficulties noted, were a big factor in bringing about this pleasing result. With three shifts of four men per shift on the job at the bottom of the shaft, it was sunk 504 feet in 144 working days, which was at that time considered a splendid record.

The report that a new-style drill was in use spread fast and aroused much curiosity, bringing numerous visitors to the shaft. For several days after sinking was started we were pestered by requests for permission to watch the machines in action. When it did not interfere too much with operations, we took as many as could be accommodated to the shaft bottom. All were amazed, and many were enthusiastic about what they had witnessed. As a result, so I was told afterward, some 30-odd BC-26's were sold within a short time up and down the Mother Lode.

And so, for all concerned—for the miner, for the mining company, and for the manufacturer—the experiment came to a satisfactory conclusion. And the then unnamed drill? You know it. Its successor is the well-nigh ubiquitous Jackhamer.

THE BC-26 JACKHAMER

When introduced, it was called a plug drill because one of the principal applications envisioned for it was the drilling of holes for the plug-and-feather method of breaking blocks of rock. The operator's right hand is on the handle used for turning the drill steel. Comparatively few of these machines were put in service, as an improved model—the BA-23—with automatic rotation was made available soon afterward. The distinctive feature of the drills of that vintage was the "butterfly" valve. This was a simple piece of forged steel with two wings that suggested its name. The valve oscillated on a central trunnion as a result of unbalanced air pressure on the wings. The valve openings were uncovered by a lifting movement instead of a sliding one, as in previous valves. The action was steady and the valves operated in cold weather when those of other designs frequently were stuck fast by freezing of the moisture in the compressed air. The butterfly-design trade mark of these drills is shown below.



SOMETHING NEW IN 1912

When electrical "Ideal" delay-action exploders took the place of conventional fuses, the miners were distrustful of them, but their fears were allayed as shaft sinking proceeded. All possible safety precautions were observed. Only one key was provided for the box that housed the blasting switch, and it was carried by the shift boss while he and his crew loaded the holes and connected the exploders to the electric-light circuit. When not in use, the circuit was broken in two places. In the picture above, the miner at the left is holding together the ends of the broken wire outside the box to restore the circuit, while the other one is closing the switch. A rock was hung on the switch handle to pull it down and to hold it open except during blasting, when it was swung closed.

This and That

Death of "Scrubby" Morrow

Howard W. Morrow, who had traveled extensively for the past 25 years as a rock-drill serviceman for Ingersoll-Rand Company, and who was known among many mining, quarrying, and contracting organizations, died suddenly at his home in Phillipsburg, N. J., on March 29. He was 60 years old. Early in life, for a reason that time has obscured, he acquired the nickname of "Scrubby," and few of his associates knew his real given name. He started work for Ingersoll-Rand as an apprentice machinist when he was sixteen years old and was in his 45th year of service with the concern when he died. During World War I he was night superintendent of the shell-manufacturing department. At the close of the war he became a rock-drill serviceman and thereafter spent much of his time in the field. He was recognized as an expert in his line, and his colorful personality won him many friends. During the present war he was assigned to help the Republic Steel Corporation increase the production of its iron mines near Port Henry, N. Y., and in connection with that work he set up two shops for reconditioning drill steel and Jackbits that are considered models of their kind.

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Color Oiling Code

The article on *Color is Power* in our April issue brought a sufficient number of requests for extra copies from industrial companies to indicate that there is considerable interest in what it had to say regarding the use of colors to promote safety. Of probably equal interest is a new color code that is to serve as a guide for the proper lubrication of machinery. The code is based on the simple idea of marking with the same color both the containers of a given lubricant and the points on machinery where it should be applied. The code covers eight general classes of lubricants, each of which is designated by an identifying color. There are five oils and three greases, and in each group there is a "general-purpose" class and a "special-purpose" class. The three remaining classes in the oil group are machine-tool spindle oils, gear oils, and hydraulic oils. The third class in the grease group covers anti friction-bearing greases.

The code has been published by the American Standards Association and was developed by a committee consisting of members from industry and from the War and Navy departments. The work was undertaken at the request of the National Machine Tool Builders Association and the War Production Board. These agencies reported that there was need for it because of the increasing amount of damage being done to machinery through the employment of unskilled labor in war plants. Faulty lubrication has led to delays in production, machines sometimes having been out of service for long periods because of difficulties in getting materials for their repair. It was stated, for instance, that the erroneous application of a grease to the bearings of a grinding machine that required high-grade machine-tool spindle oil had caused the machine to lie idle for several months.

Similar color-code identification systems have been adopted by individual companies in recent years and some have been developed by lubricant suppliers for the use of their customers. It is hoped that the new standard will bring about a unification of these systems.

International News Photo

MAKES SIMULATED DIVE EQUAL TO 550-FOOT DEPTH

On April 29, Jack Browne of Milwaukee, Wis., withstood a pressure of 244.75 pounds per square inch in a tank containing 8 feet of water. This is equivalent to the pressure encountered at a depth of 550 feet in sea water. Under these artificial conditions Browne set a new record, the previous one of 500 feet having been established by Navy divers in a tank at the Washington Navy Yard in August, 1938. Browne made his "dive" in a compression chamber and wore a helium-oxygen helmet and a 50-pound diving suit. The pressure was gradually increased by introducing compressed air and reached the maximum after 10½ minutes. The test was witnessed by a group of naval officers acting as unofficial observers, and Browne talked with them and a physician by telephone during his submergence. Browne is a 28-year-old civilian and is president of the Diving Equipment & Salvage Company, Inc., of Milwaukee. The picture was taken through a porthole in the chamber while the diver was undergoing decompression.

★ ★ ★

Compressed Air at Anaconda

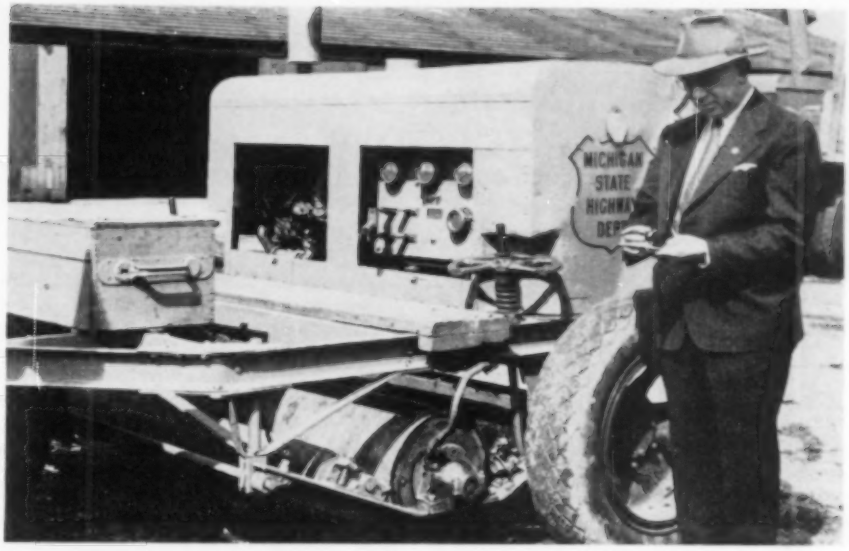
Some interesting information concerning the compressed-air supply at the Butte, Mont., mines of the Anaconda Copper Mining Company were published in the April 13 issue of *Copper Commando*, official newspaper of the company's Victory Labor-Management Committees. Approximately 100 million cubic feet of air is compressed there daily and used in practically equal quantities on the surface and underground. One ton of air, which is equivalent to 32,680 cubic feet at the Butte altitude, is required for each 3½ tons of ore produced.

"In the larger mines," the article reads, "there is usually a 10-inch air line going down the shaft. . . . . A 4-inch or smaller line carries the compressed air from the 10-inch shaft line to the working places on the underground levels and by tapping these. . . . . power is furnished for drilling. Any miner will tell you it's a whale of a lot easier and faster to drill today with power furnished than it was in the old days with a hand drill. But that is only one of the hundred uses of compressed air around Butte. It furnishes the power for hoisting many

of the cages and skips; for the air hammers in the blacksmith shop; for the air-driven tools in the machine shops; for the boring machines in the carpenter shops. You'll find compressed air used all over the Hill in the shops and mines."

There are four compressor plants: the Leonard, the Bell, the Never Sweat, and the Butte Hoist. The largest of these is the Butte Hoist, a 70x320-foot structure housing eight large compressors set in line. These machines take in through filters 60,000 cfm. of air at atmospheric pressure, which is about 11¾ pounds per square inch at that altitude. It is compressed in two stages to 90 pounds per square inch. From the machines the air passes to large receivers outside the building. These receivers are connected by an 18-inch pipe line with sixteen others that are disposed horizontally and arranged in a line at a point about ¼ mile away and downhill. A short distance up the hill from the lower bank of receivers there is a steel water tank, 100 feet in diameter and 10 feet deep, which also is connected with them by a 42-inch line. The hydrostatic head just balances the 90-pound pressure of the air, which enters the receivers at the top. If the air pressure drops, water enters at the bottom and restores the pressure.

"In other words," the article states, "this hydrostatic system is used to maintain a uniform pressure on the air in the distribution lines to the mines and shops. It is aimed to keep the pressure of the air between 90 and 86 pounds at all times. If the pressure goes down, as indicated by the lowering of the water in the steel water tank, it is necessary to cut in other compressors."



ROAD MAGNET SAVES AUTO TIRES

Put in use by the Michigan State Highway Department, this electromagnet has collected 1200 pounds of ferrous objects from 1448 miles of trunk-line pavements and 152 miles of gravel roads, an average of ¾ pound per mile. It is designed to lessen punctures during the period of rubber scarcity. The roller that travels near the highway surface is revolved forward slowly by a belt take-off from the trailer wheels and is magnetized by current from a generator mounted above it. It picks up pieces of tramp iron and steel and carries them around to a point where the current is cut off, permitting them to drop into a bin. The magnet will attract anything from a small tack to a crowbar.

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Jack McIver Passes

Jack L. McIver, who made a fortune from mines he discovered and developed but who took greater pride in his notable record as a hand rock driller, died recently at Beverly Hills, Calif., where he had lived for six years. He was 66 years old. McIver competed for many years in the hand-drilling contests that featured old-time-mining-camp holiday celebrations and was recognized as one of the best men ever to swing a double-jack. At Globe, Ariz., in 1907, he and his partner Jim Pickens, who came from the Coeur d'Alene District, sank a 47½-inch hole in fifteen minutes, and in some camps that was accepted as the world record. In after years, McIver found the United Eastern gold mine at Oatman, Ariz., and developed it into a highly successful enterprise, using money advanced by his former underground working companions at Globe, Bisbee, and Oatman. He also discovered the Irene zinc mine at Globe, and subsequently became president of several companies that operated these and other properties. He was a native of Montreal, Canada. In recording his death, *The Mining Journal*, published in Arizona, referred to him as " a miner's miner."

★ ★ ★

Fire Bomb Genesis

The jellied-gasoline incendiary bombs that are being showered on Japanese cities by the millions grew out of efforts of Prof. Louis Fieser of Harvard University to rid his lawn of crab grass. In an attempt to burn it out he tried a blowtorch, kerosene, then plain gasoline, all without success. Soon afterward he discovered a substance that thickened gasoline until it jelled. He applied some of the product to the crab grass, lighted it, and burned the grass to a crisp. This incident formed the basis of experiments by Professor Fieser and his assistants that resulted in the viscous orange-colored, gelatin-like, inflammable gasoline that is now designated as Army M69 oil incendiary.

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Powerful Electron Microscope

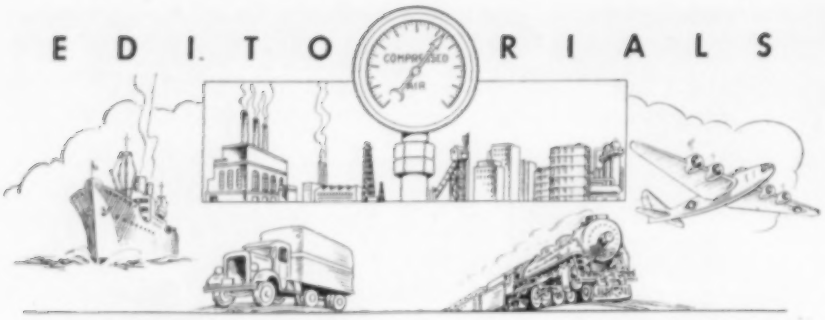
The Radio Corporation of America has built a 1-ton electron microscope that magnifies the windpipes of mosquitoes to a diameter of approximately 2 inches, and it is revealing important information that will help fight diseases. Highly magnified photographs, known as electron micrographs, have shown how the body protects itself from infantile paralysis, smallpox, influenza, the common cold, and other ailments by means of organisms in the blood stream that attack the various viruses. The microscope cost $13,000, and it is the ninetieth of its kind to be put to use in the United States. It was purchased by the National Cancer Institute, but will be available for studying other diseases.

★ ★ ★

Jet-Plane Cabin is Pressurized

In the new Lockheed P-80 jet-driven fighter plane, warm air, under pressure, flows from the impeller-compressor to the inclosed pilot's cabin, thus performing the dual function of pressurizing it and keeping it at a comfortable temperature. The pilot can consequently breathe normally without wearing an oxygen mask while traveling at high speed in the substratosphere and does not have to wear heavy clothing. These factors, plus the freedom from vibration that characterizes a jet-propelled plane, are said to reduce pilot fatigue to a minimum. The jet engine, which is made by General Electric Company, has only 10 percent as many moving and removable parts as a conventional aircraft engine.

EDITORIALS



POSTWAR ROADBUILDING

ALL the signs point to a postwar boom in road construction. There is need for more highways, the money is available, and a roadbuilding program possesses the virtue of putting large numbers of men to work, both directly and indirectly.

Some of our roads have been taking a severe pounding from wartime traffic. New construction has been at a standstill, and maintenance has been meager. Several years of work are envisioned in bringing our existing networks back to first-class condition, and the files of state highway departments are bulging with plans for new construction. Most of the states have fortunately been setting aside the funds that have been piling up for their highway divisions and earmarking them for postwar work. In some of the more heavily populated states the amounts available are well above the half-billion mark.

Cement mills and manufacturers of roadbuilding machinery are looking forward to capacity production for sometime to come. Officials of the road-construction agencies are predicting billion-dollar programs in single years as soon as our national economy can be adjusted to make them possible. For the first of these will be required $250,000,000 worth of machinery and $500,000,000 worth of materials, according to an estimate by Charles W. Upham, engineer-director of the American Roadbuilders Association. He added that the highway jobs that are planned from coast to coast will employ 800 million man-hours of labor.

"If essential relief is to be given without delays that may entail serious consequences," he stated, "equipment replacement must begin at the earliest possible day consistent with national security. Thousands of roadbuilding units are virtually worn out, and most of the remainder now in service are in such condition that a few months' strain would relegate them to the scrap heap."

The construction program will be intensified by reason of the fact that Federal aid has for the first time been extended to county and local secondary routes. There are 2,400,000 miles of these, ranging from gravel-coated roads to almost primitive trails. Most of them are used, however, for moving farm products to markets and are essential to our national economy. Putting them in good condition will expedite traffic and benefit both producers and consumers. Nearly half of our farms are located on dirt roads, and transportation difficulties increase food costs and limit farm buying of manufactured goods. Main state highways total 415,000 miles and have carried heavy traffic burdens with subnormal care for the past four years. About 75,000 miles of them are twenty or more years old and will have to be entirely rebuilt.

Road construction is decidedly not boondoggling, for good highways pay their way. Numerous surveys show that they save the motorist at least two cents a mile in driving costs. As the average car covers about 8000 miles in a normal year, the monetary benefit from traveling on smooth surfaces is apparent.

Mr. Upham said that he had yet to meet anyone who would venture to estimate in terms of dollars the value of adequate highways. "Actually," he stated, "the nation's economy is built around the motor vehicle and the road. Take the road away, and the entire economic structure would collapse."

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PLANTS WITHOUT SOIL

THIS is a propitious time for the article on hydroponics that appears in this issue. With many of our readers engaged in Victory gardening, minds are running along the lines of growing things, and doubtless some of them will resolve to have a fling at this new kind of indoor gardening after Nature closes the gates on outdoor activities. Happily, the author has given all the information anyone needs to get going.

The average person who starts raising vegetables or flowers in a tank will be merely pursuing an interesting hobby. However, there is another and more important side of the subject. Some authorities advocate making a serious business out of hydroponics and see untold possibilities in it especially in semiarid regions where there is insufficient water to cultivate the ground in the conventional manner. Among them is Dr. S. E. Soskin, who would apply the method on a large scale in Palestine.

A farmer in Palestine, according to Waldemar Kaempffert, science editor of the *New York Times*, practices agriculture intensively. He can raise 4 tons of potatoes on half an acre of land in one season and obtain two additional crops from the same plot in the course of a year. There is ample sunshine and no frost. However, the supply of water for irrigation is definitely limited, so limited, in fact, that only a relatively small part of the available land can be brought under cultivation. This is especially true of the southern section, the Negev, which comprises nearly half of the nation's area.

The solution of the problem, says Doctor Soskin, is to grow vegetables in tanks. The chemicals needed by the plants are put in a nutrient solution in the proportion of 1 to 1000, whereas they occur in soil in a ratio no greater than 1 to 10,000. Consequently, and this has been proved beyond doubt experimentally, ten times as many vegetables can be raised in a tank as in a like area of soil.

For the growing of 80 tons of potatoes by ordinary methods a farmer will not only require ten acres of ground but also farming machinery, sheds, etc., and two laborers to assist him. He can raise the same crop in two acres of tanks, with no tractor or horses, with no cultivating equipment, and with no hired help. Water, which is the priceless ingredient, will be saved through a decrease in evaporation because the tank area is only one-fifth of the equivalent ground area. Where land is farmed, some of the water percolates to levels below the root system where it is of little use. This cannot happen in hydroponics because the tanks have bottoms.

The quantity of chemicals needed can be computed in advance, as can all other costs. There is no gambling with poor soil, no waiting for rain. Weeds, insects, and pests are absent. There is no plowing, hoeing, or irrigation, not even any bending or kneeling, for the tanks can be set up at any convenient height. They can be made of metal, concrete, wood, clay, or any other suitable material. With good care they will last ten years, and 30 crops can be raised in that period in the Holy Land.

Doctor Soskin and Prof. William F. Gericke, who gave hydroponics its name, have proposed to the UNRRA that it introduce tank farming in the liberated Mediterranean countries as a means of feeding the millions of people who are near starvation. It has been decided to try out the idea in Greece. An important phase of the Soskin-Gericke project is the establishment of a school for hydroponics in Palestine, using Doctor Soskin's demonstration farm of about 24 square yards in Jerusalem as a nucleus. The purpose of the school is to train instructors.

Airplane Engines of the Future

"WHILE the reciprocating engine will undoubtedly continue to hold its present position in the field of low power and for planes of low speed, the gas turbine will come into its own both as a jet engine and for driving propellers in high-powered planes and for high-speed flight."

These are the conclusions of two spokesmen for the Westinghouse Electric Corporation—Charles D. Flagle, a design engineer in the Aviation Gas Turbine Division, and Frank W. Godsey, manager of the New Products Division—as expressed last month to a group of trade-journal editors in New York.

"Of the three types of power plants," they stated, "the gas turbine-propeller engine has characteristics that give it superiority over the reciprocating engine in all speed ranges and over the jet engine in low and intermediate speeds. The jet is preëminent in the highest speed range." Figure 1 shows the probable fields of use of the three types.

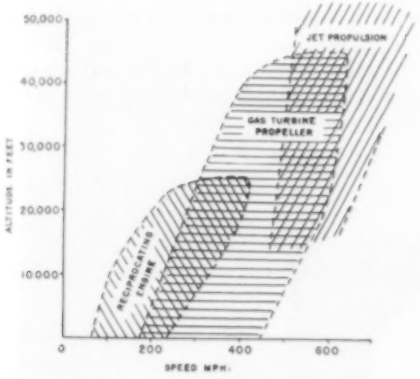


FIGURE 1

Conceding that the reciprocating aircraft engine is one of the great technical accomplishments of our age, the speakers expressed the opinion that major increases in its present power ratings can probably be attained only through improvements in fuels or by adding more cylinders. The diameter or frontal area is already limited by allowable piston speeds, larger engines mean longer engines, and the specific weight is more apt to increase with power rating than to decrease. The reciprocating engine is by nature adapted for cruising rather than for sustained high-speed flight. Its greatest efficiency and greatest reliability are obtained only when the engine is operated below 60 percent of its rated power. An underpowered airplane is continually plagued by power-plant troubles of a mechanical nature. Following are other of their observations.

The reciprocating engine, in its normal cruising-power range, is a very efficient means of converting fuel energy into shaft horsepower. However, its application to aircraft is complicated by many difficult problems, among which are the necessity for supercharging at high altitudes, severe vibration, excessive weight installed as compared with dry engine weight, and high nacelle drag and engine-cooling power losses. It presents a dismayingly large frontal area when placed in a wing nacelle, and the total profile of the power plant frequently exceeds that of the fuselage. Similarly, the type requires large volumes of cooling air that must be forced around the cylinders of air-cooled engines or through the radiators of liquid-cooled engines, as well as through numerous accessories and oil coolers.

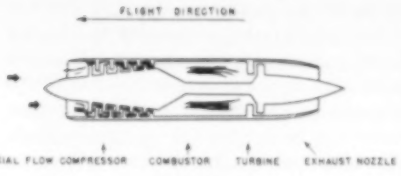


FIGURE 2

The axial-flow jet-propulsion engine on the other hand, is a slender package capable of delivering almost constant thrust at all speeds from take-off to dive, maximum. Throughout this speed range, fuel is burned at a practically constant pounds-per-hour rate, and changes in speed have but little effect on thrust or fuel consumption. Further, the jet propulsive efficiency is approximately proportional to speed. These factors will lead to the use of jet engines in high-speed aircraft. At low speeds fuel-consumption rates are exhorbitant, compared with planes driven by propellers.

Figure 2 shows an axial-flow-type jet engine in which the compressor, combustion chamber, and turbine are arranged in line so as to present minimum frontal area. Its principal advantages are simplicity and light weight. The installed weight is little higher than the dry weight, since little oil is needed for lubrication and the engine itself requires no provisions for external cooling.

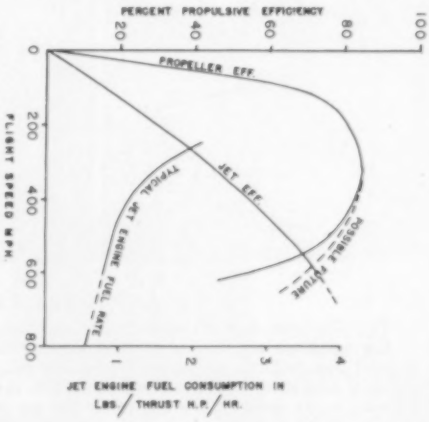


FIGURE 3

The jet engine's thrust is relatively constant over normal airplane speed ranges. Therefore the rating of a jet engine is usually stated in terms of thrust rather than horsepower and means nothing from a power standpoint until the speed also is given. A thrust of 1 pound at a speed of 375 miles per hour is equivalent to 1 hp. At lower speeds the power rating decreases and at higher speeds it increases in direct proportion.

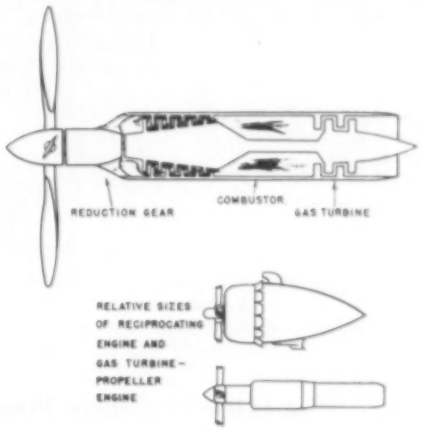
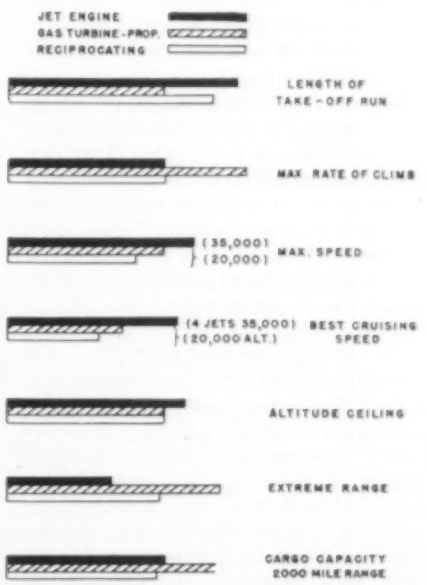


FIGURE 4

An adjustable-pitch propeller is capable of converting shaft power into thrust power rather efficiently over a wide range of airplane speeds, but the jet's efficiency is quite low at low speeds and does not equal propeller efficiency until flight speeds of about 500 mph. are attained (Figure 3). Jet propulsion gives high-speed performance at the expense of range and low-speed characteristics.



GENERAL COMPARISON

This chart compares the characteristics of the three types of airplanes listed in the accompanying tables.

The gas turbine geared to a propeller, Figure 4, has the advantages of the jet engine with respect to drag reduction and ease of installation and at the same time retains the high propulsive efficiency of the propeller at low speeds. In appearance, it will be a symmetrical machine, its reduction gear concentric with its rotor. Its diameter will be less than half that of a conventional engine of comparable power, permitting it to be easily buried within a fuselage or wing.

The gas turbine for propeller drive operates on from four to eight times the quantity of air used by a reciprocating engine of like power. A large exhaust-jet thrust is available to supplement the propeller, for normally about 20 percent of the useful power remains in the exhaust gases as kinetic energy. The proportion of useful power remaining in the exhaust to power delivered to the propeller can be controlled by the designer. The installed weight of the geared gas-turbine engine should be less than three-fourths that of an equivalent reciprocating-engine installation.

The following tables compare the three types of future aircraft under take-off and cruise conditions:

TABLE 1- TAKE-OFF CONDITIONS

	Gross Wt. (lbs.)	Installed Power Plant Wt. (lbs.)	Fuel Wt. (lbs.)	Take-off Thrust (lbs.)
Conventional	120,000	20,800	40,000	28,000
Turbine propeller	120,000	15,200	45,600	44,000
Jet propelled	120,000	8,000	52,800	24,000

TABLE 2- CRUISE CONDITIONS (20,000 FT. ALTITUDE)

	Best Cruising Speed Mph.	Miles per Lb. Fuel	Extreme Range Miles
Conventional	250	0.120	4800
Turbine propeller (4 engines)	300	0.125	5700
" " (2 engines)	280	0.145	6600
Jet propelled (2 engines)	350	0.050	2650
" " (4 engines 35,000 ft. alt.)	460	0.066	3500

Portable Washing Machine for Streamliners

WITH passenger trains kept on the move as they now are and with the labor situation what it is, it is something of a job to keep the outsides of coaches and locomotives clean. But the work must be done, and to expedite it, the Chicago & North Western has installed a car-washer at its streamliner servicing yard in Chicago, Ill. The equipment was constructed by the Whiting Corporation and is mounted on wheels so it can be pushed by way of cross rails to straddle any one of four tracks over which the diesel trains are backed into the yard. When in position, the machine is held firmly by ground rings and clamps.

The unique feature of the arch-type structure are the fiber brushes, of which there are two on each side. They are cylindrical in form, mounted vertically on swinging arms, and are rotated at the rate of 240 rpm. through V-belt drive by electric motors. One is 15 inches in diameter and 9 feet high and, as a train travels along, scrubs it from the edge of the roof down to the bottom. This brush has a self-aligning feature that permits it to adjust itself to the angle of the side walls. The other brush also has a diameter of 15 inches but is 3 feet 10 inches long. It cleans the windows which, in modern streamliners, are virtually flush with the car bodies. The scrubbers are mounted to prevent turning on the shafts and may be held against the surfaces at a predetermined pressure by means of counterweights. When not in use they are swung aside, leaving the track free for the passage of trains.

Back of each brush is a spray pipe that keeps the fibers well soaked with water; and on each side of the washing machine, both at the entrance and exit, water is directed at right angles against the cars from a vertical pipe with eleven nozzles spaced on 10-inch centers, thus wetting them well before and after scouring. Drain pans and splash plates catch the dripping water and direct it into sewer openings. In cases where water alone will not do a thorough job, North Western applies a cleaning solution, and for this purpose has erected two vertical standpipes, each provided with three nozzles, on opposite sides and 100 feet ahead of the tracks where the washing is done. The solution is stored in two 80-gallon tanks mounted on wheels, and compressed air is used to force it into the standpipes, from which it issues in fanlike sprays that cover the cars from the top of the letter boards to the lower edges of the skirts. Then, as the train is backed through the machine, it is thoroughly brushed and rinsed.

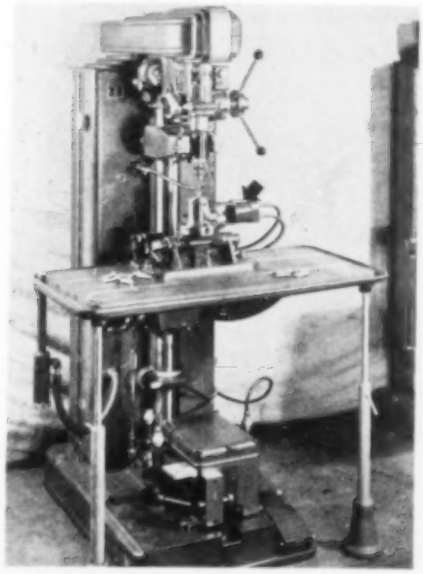
Streamliners are run through the machine on their way to the servicing yard at the rate of 80 feet a minute. Since its installation last August, the equipment has cleaned on an average 60 cars a day, including twelve diesel-electric locomotives, with no manual aid other than that required to operate the machine, to wipe windows to prevent streaks, and to wash the front ends of the locomotives and the rears of observation cars. This is not the full capacity of the unit; but, even so, the savings effected are said to be large.

WASHED FOR THE NEXT RUN

The Chicago & Northwestern streamliner at the left has just passed through the washing machine straddling one of the four tracks provided for that purpose and over which passenger trains are run into the Chicago servicing yard. The long and short brushes are attached to their vertical shafts in staggered half sections so as not to leave marks on the car surfaces and are kept soaked with water when in use. They clean the sides and windows as a train backs through the washer at the rate of 80 feet a minute.

Industrial Notes

Warner & Swasey have announced an improved type of precision tapping and threading machine that is equipped to function automatically. It embodies a Zagar air-operated holding fixture, indicated by an arrow in the accompanying picture, that saves the time normally required to raise the spindle more than an inch above the work for loading and unloading, thus increasing production. With the new set-up, the operator's hands are free to feed the machine: he simply depresses or releases a treadle, in that way tilting the fixture about



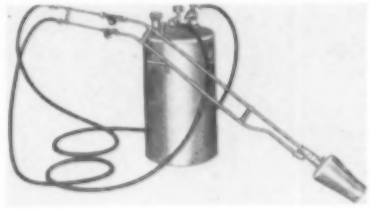
20° or returning it to the vertical position. A microswitch then starts the operating cycle. When it is completed the machine stops. Compressed air serves only to actuate the locking and unlocking mechanism, insuring uniform holding power regardless of variations in air pressure. Standard 14 AC No. 2 collets are used and open and close as the fixture is tilted. The manufacturer stresses the fact that the collets do not move vertically in closing and that the work can therefore be held to close tolerances in second operations such as milling slots, counterboring, etc. There are provisions in the fixture for a stop to insure duplicating parts.

Superstructures of the 18,000-ton transports leaving the ways of the Ingalls shipyards at Pascagoula, Miss., are built of corrugated instead of the usual flat steel plates. As a result of this simple expedient it is possible to eliminate many of the stiffeners and much of the welding ordinarily required in their construction.

Lusco Plastic-Seal is the trade name of a resinous-base compound that is intended primarily to plug cracks in motor blocks, cylinders, valve ports, and combustion chambers but may be used to stop leaky joints in liquid systems, automobile radiators, for filling in porous welded sections, etc. It is made by the C. F. Lusk Company and is said to find its way to the defective points, forming a plastic seal that resists vibration.

A welder's reference chart which tells him what shade of filter lens is required for each of the different welding operations has been prepared by the American Optical Company, Southbridge, Mass. The proper choice is of importance especially in electric welding, and will help him to safeguard his eyesight and, incidentally, to speed up his work. Copies of the chart can be obtained free upon request.

For jobs where a flame of 2000°F. is needed and where a supply of compressed air is available, Aeroil Burner Company, Inc., recommends its improved atomizing-type torch. The unit consists mainly of a fuel and air tank; of long, paralleling fuel and air pipes that constitute the handle; and of a head made up of a mixing chamber, a nozzle, and a combustion chamber that is vented so as to combine free air with the flame. The latter can be regulated in length from 6 inches to 144 inches and is said to burn steadily without pulsation. Fuel, diesel, or furnace oil may be used, as well as kerosene or distillate, and consumption varies from 2 to 12 gallons per hour. Air requirements and pressures range from 7 to 21 cfm. and from 30 to 120 pounds,



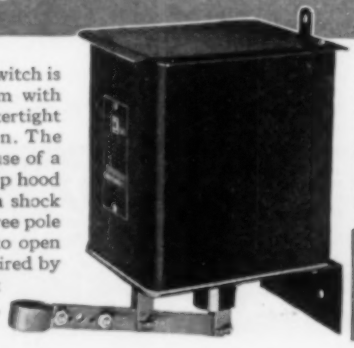
respectively. Aeroil torches come in three sizes and feature connecting oil and air hoses with dirt- and leakproof unions that prevent interchanging those flexible lines. Preheating, starting pulverized coal and coke fires, skin-drying foundry molds, and lighting cupolas are but a few of the applications for which the equipment is designed. For portability, the pressure tank can be mounted on a hand truck built for the purpose.

Cork-filled tape has been put on the market by the J. W. Mortell Company as an insulating material for cold-water pipes of 1-inch diameter and less. It is wrapped around piping, valve bodies, and fittings where condensation and drip constitute a problem. It is designated as Nodrip Tape.

Something new in services is being offered by an Illinois concern for the protection of workers who are exposed to fire or explosion hazards. At a nominal fee, it collects aprons, coveralls, shirts, pants, hats, and gloves; washes them; fireproofs them; and returns them ready to wear.

Marine FLOAT SWITCH

DRIPPROOF AND WATERTIGHT
HIGH SHOCK CONTACT BLOCK
TWO OR THREE POLE
CLASS 9036 • TYPE AW-H



• The class 9036 type AW-H float switch is built for Marine Service to conform with requirements for a dripproof and watertight device of shockproof construction. The switch differs from standard in the use of a special sheet steel enclosure and drip hood with gasket seal and a special high shock bakelite contact block of two or three pole form. The switch can be arranged to open or close on rise in liquid level as required by application. Mounting is three point by means of bracket flange and foot, as illustrated. **Write for Bulletin 563.**

ELECTRICAL RATINGS

Voltage	Single Phase A. C.	Polyphase A. C.	D. C.
110V.	2 H.P.	3 H.P.	1 H.P.
220V.	3 H.P.	5 H.P.	1 H.P.
440-550	5 H.P.	5 H.P.	.....
32V.	.....	.....	½ H.P.

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Industrial Literature

E. F. Houghton & Company, 303 West Lehigh Avenue, Philadelphia 33, Pa., is offering gratis copies of the fourth edition of its booklet, *Digest of Corrosion Preventive Specifications*. The same company also has available for distribution a new folder, *Houghton's VITAL Diesel Engine Oils*.

The Reynolds Electric Company, 2650 W. Congress Street, Chicago 12, Ill., offers free copies of a booklet, *Magic Heating Plant of the Human Body*, which explains a method of cooling homes and offices in summer by the use of the company's RECO Radi-Aire Circulators.

General Electric Company, Schenectady, N. Y., has issued a bulletin *Motors and Control for Hazardous Locations* that it is offering free. It defines hazardous places, lists design and test requirements, and tells how to apply explosion-proof equipment. Other new G-E publications are *Sintered Alnico Magnets* and *Electric Tachometers to Measure Speed*.

A profusely illustrated 34-page brochure, *In War and Peace*, may be obtained from Bucyrus-Erie Company, South Milwaukee, Wis. It reproduces photographs of dozers, scrapers, dozershovels, and other tractor-mounted machinery in use on the war and homefronts. It points out that the equipment has given the Allies advantages over their enemies by enabling them to build airports and other vital structures in a matter of hours.

Research data contained in theses written for masters' degrees from technical schools and universities and hitherto largely buried in the archives of those institutions are being made available for the first time. Those that are considered of interest to industry and research workers will be indexed in the technical *Digest Index* issued by The National Research Bureau, Inc., 415 North Dearborn Street, Chicago 10, Ill. Material wanted will be supplied on microfilm.

A new edition of a handbook that gives essential information about U-68 and U-69 tanks and pressure vessels has been issued by William Fogle, 1202 South Norton Ave., Los Angeles 6, Calif. It is intended for the use of fabricators, engineers, draftsmen, estimators, and sales engineers. It gives tabular data on allowable working pressures, volumes in U. S. gallons, and other pertinent subjects, as well as information on layout and welding procedure. The title is *Fogle's No. 1 Tank and Pressure Vessel Handbook*. Copies are obtainable from the company. Price, $5.00.

The Lonn Manufacturing Company, Inc., has published a new catalogue covering products of interest to many users of compressed air. It includes detailed information on the concern's "Air Saver" blowguns, spray guns, and water guns. All make use of a valve that embodies only three parts and that is controlled by an internal piston or throw-pin that extends back into a flexible-hose handle. Flexing of the hose by hand pressure opens the valve and permits air or water to flow. When the pressure is released, the hose returns to the straight position and the valve is closed. These valves are applicable to various types of equipment and are made in various sizes for air pressures up to 200 pounds. The catalogue may be had by writing the company, P. O. Box 394, Indianapolis, Ind., and requesting Catalogue No. 57.

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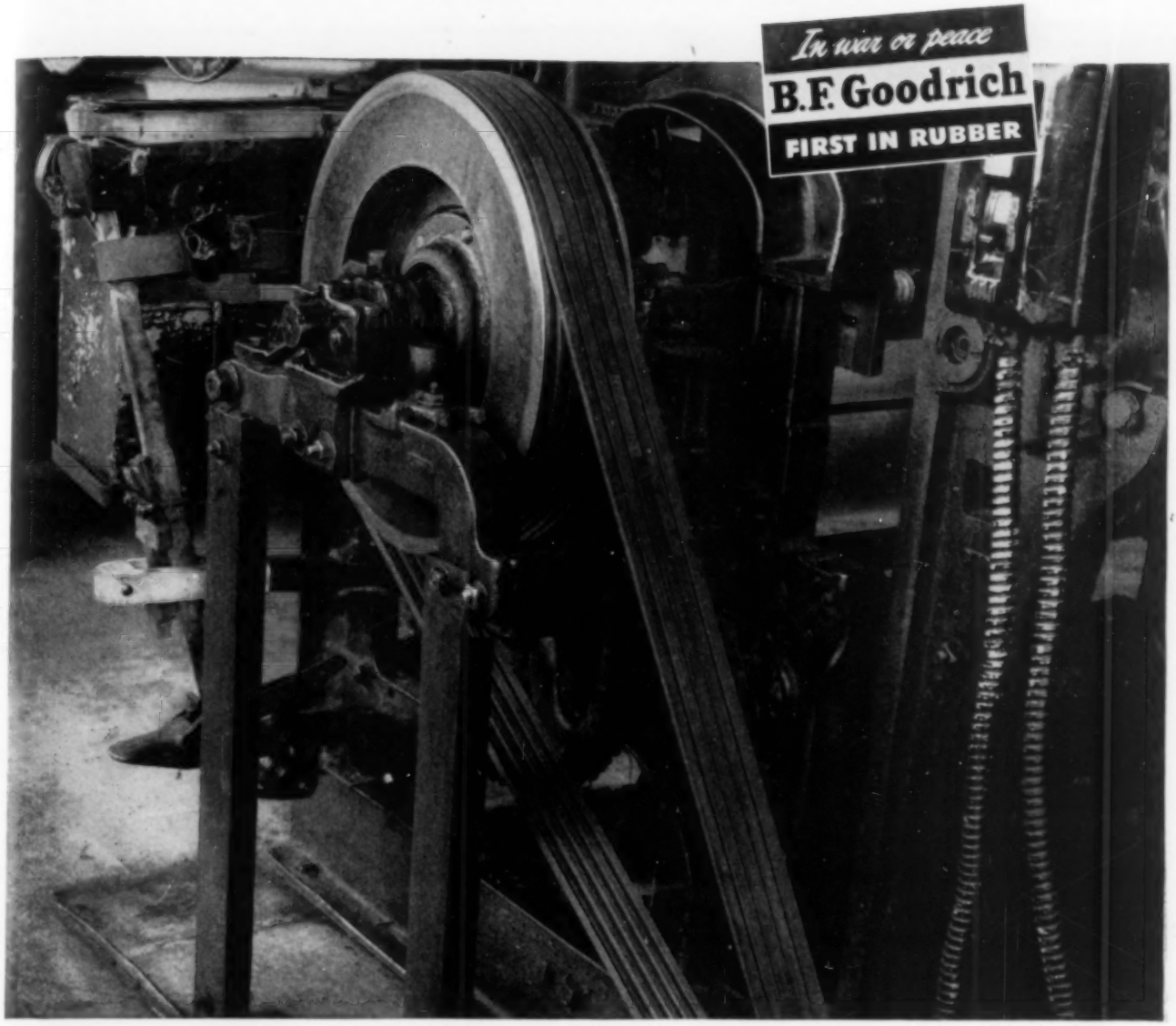


B.F.Goodrich multiple V-belt drives here outlast gear drives 4 to 1

Successful experience in textile loom service points way to increased industrial use

FOR years, textile men said that V-belt drives couldn't be used on heavy duck looms. And they were right —until recently. The low-stretch, non-resilient V-belts of a few years ago couldn't meet the demands of this severe and exacting service. They were all right for spinner or twister frames —but not for looms.

Then B. F. Goodrich developed the shock absorbing, resilient, high flexing V-belt that is known throughout industry today. Six years ago loom tests were begun. Since then, B. F. Goodrich multiple V-belt drives have proved in actual service that they offer the following distinct advantages over gear drives for textile looms:

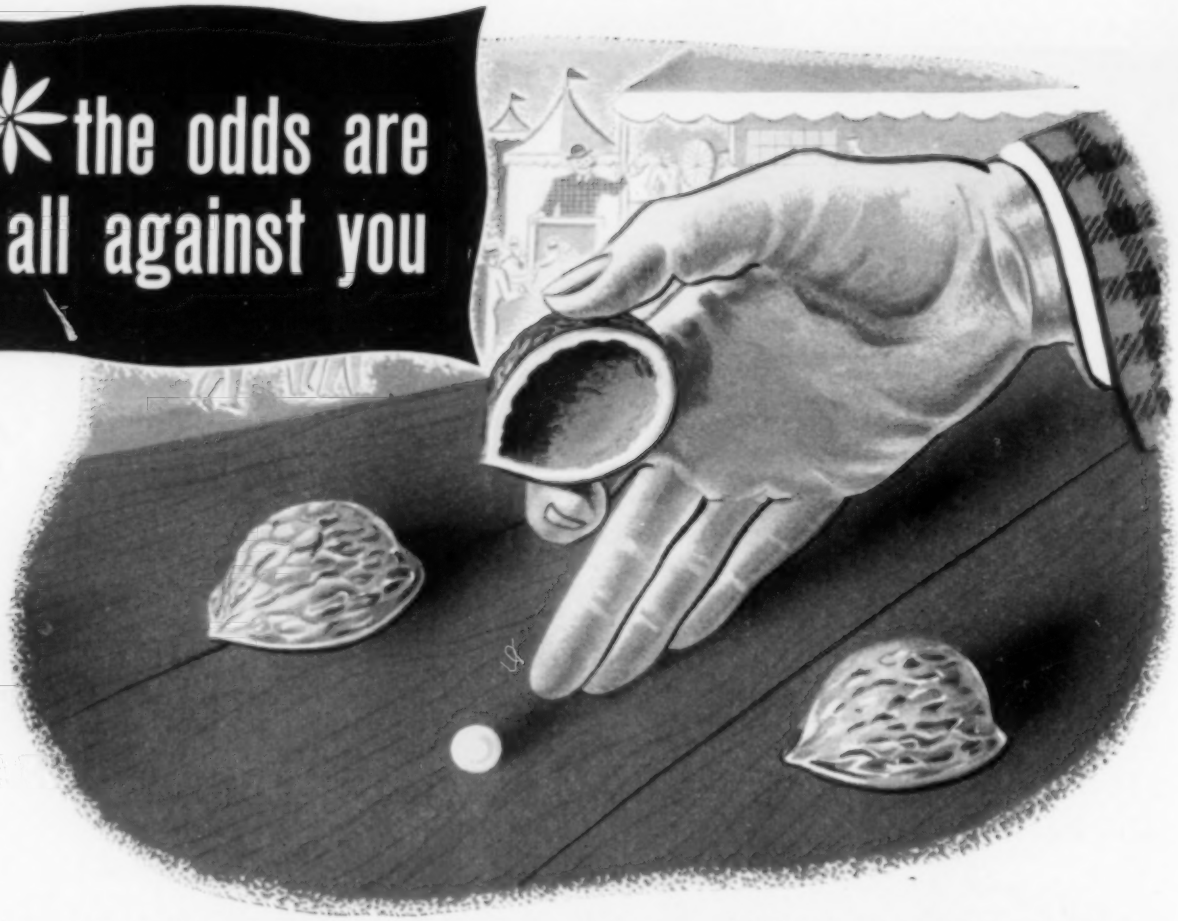
1) Average gear life, 6 months; average V-belt life, 2 years. 2) Sharply reduced maintenance time and costs. 3) Smoother operation of the delicate looms. 4) Reduced noise. 5) Reduced time and cost for replacement. 6) Shock absorbing qualities not present in positive transmission. 7) V-belts absorb peak loads, save and extend life of loom parts. 8) A quick and cheap way of changing loom speed by using a variable pitch pulley.

Your B. F. Goodrich distributor will be glad to translate these *proven* advantages into terms of your own power transmission needs. Or if you have any other problem involving the use of rubber, the chances are that it can be solved by one of the 32,000 B. F. Goodrich rubber products. *The B. F. Goodrich Company, Industrial Products Division, Akron, Ohio.*

B. F. Goodrich

RUBBER *and* SYNTHETIC *products*

✳the odds are all against you



✳Gambling is fun when the odds are somewhere near even — but like trying to beat the old shell game — taking a chance on dust getting into your power equipment always ends in disaster.

When you protect engines and compressors with AAF air cleaners you prevent the unnecessary costly, time-consuming breakdowns which always result from excessive wear caused by abrasive dust and grit that gets into their vitals.

Throughout the nation, Cycoil cleaners are prolonging the useful life of valuable power equipment — permitting uninterrupted operation on stepped-up running time and accelerated production schedules.

The cost of Cycoil's "preventive maintenance" is insignificant compared to savings in wear, running time and man-hours. Write for free literature.

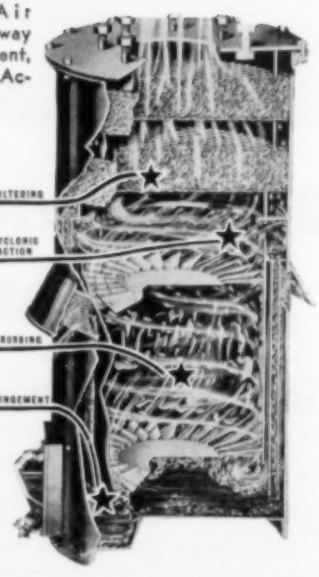
Cycoil Oil Bath Air Cleaner provides 4 way cleaning — Impingement, Scrubbing, Cyclonic Action and Filtering.

Filtration thru Double Cells completes cleaning action eliminating oil mist from air. 4 FILTERING

Cyclonic action induced by vanes throws oil containing dust outward. 3 CYCLONIC ACTION

Scrubbing action thoroughly mixes air and oil, entraining all dust particles. 2 SCRUBBING

Impingement of dirty air against oil, deposits the heavier dust particles immediately. Oil and air mixture then passes upward with whirling motion thru vanes to succeeding cleaning steps. Cycoil bulletin No. 130 D gives complete information. 1 IMPINGEMENT



A complete line of Engine and Compressor filters have been developed by AAF engineers thru years of experience with every kind of air cleaning problem. Bulletins descriptive of each type from unit to large automatic, self-cleaning filters for multiple unit service are available without obligation.

AAF

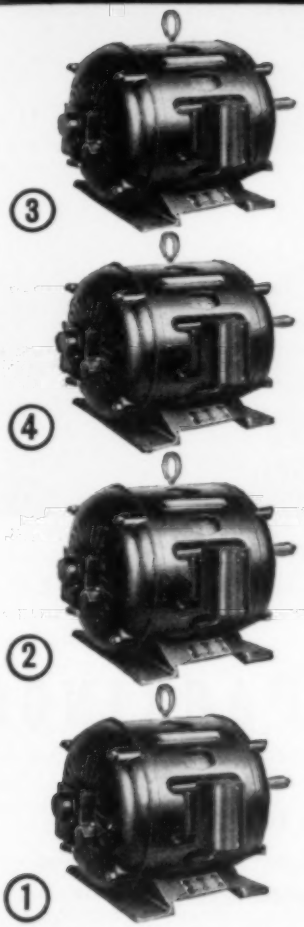
AMERICAN AIR FILTER COMPANY INC.

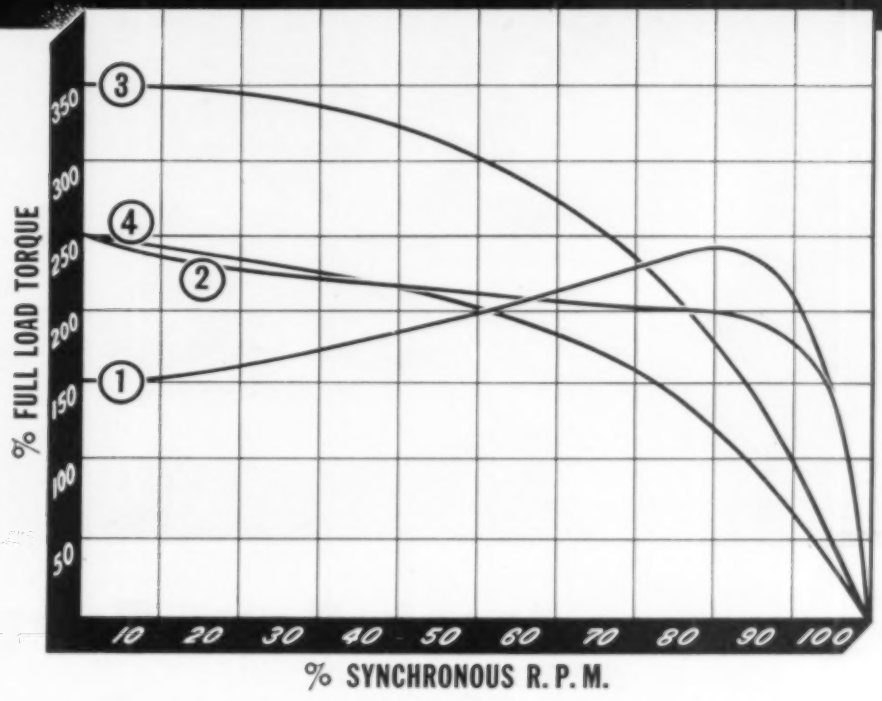
INCORPORATED

402 Central Avenue, Louisville 8, Ky.—In Canada, Darling Bros., Ltd., Montreal, P. Q.

Which Squirrel-Cage Motor for the Job?

THESE FOUR MOTORS LOOK ALIKE—BUT THEY ARE BUILT FOR ENTIRELY DIFFERENT APPLICATIONS





The selection of the right type of motor for any given application involves a thorough knowledge of the electrical characteristics of motors. These four motors look alike externally and internally, but they are entirely different in electrical performance. The same mechanical parts are used in their construction and their windings are insulated alike, but each type is suitable for a certain kind of job. All of their windings are braced for full-voltage starting and none of them need be operated with voltage-reducing devices. The essential differences between these motors are apparent only from a study of their speed-torque curves.

CURVE 1 is a typical speed-torque curve of a Wagner type RP-1 normal-torque motor. This motor has a higher breakdown torque at a higher speed than any of the others and therefore is capable of carrying greater momentary overloads. It has a starting torque fifty percent greater than the full-load torque, and a full-load speed of about three percent less than synchronous speed. This type of motor is suitable for such a wide variety of applications that it is often called a general-purpose motor. It should not be used on jobs which require high-torque, punch-press, or elevator motors.

CURVE 2 is a typical speed-torque curve of a Wagner high-torque type RP-5 motor. This motor has a flatter torque curve and considerably less breakdown torque than the type RP-1. It has a starting torque from two to two-and-a-half times the full-load torque and about the same full-load speed as the type RP-1. The RP-5 motor is suitable for driving crushers, compressors, and other machines which are hard to start.

CURVE 3 is a typical speed-torque curve of a Wagner type RP-6 punch-press motor. This motor develops its greatest torque at standstill and has a starting torque from three to three-and-a-half times the full-load torque. It has a much lower full-load speed than the type RP-1 and RP-5 motors and therefore slows down considerably when the punch-press forms or pierces its work, allowing the punch-press fly-wheel to deliver its stored energy and reducing the work done by the motor. The RP-6 motor should be used on any machine which has a heavy flywheel or flywheel effect.

CURVE 4 is a typical speed-torque curve of a Wagner type RP-7 or elevator motor. It has lower starting torque and lower full-load speed than a punch-press motor and therefore can smoothly accelerate and operate an elevator, hoist, or dumbwaiter which must be started, stopped, and reversed frequently.

For Complete Information write for Motor Bulletin MU-185 which fully describes Wagner squirrel-cage polyphase motors, as well as all other types of Wagner single-phase, polyphase, and direct-current motors.

M45-10

MOTORS are but one of several **WAGNER PRODUCTS** serving industry.

Other WAGNER PRODUCTS:
AIR BRAKES
BRAKE LINING
HYDRAULIC BRAKES
INDUSTRIAL BRAKES
INDUSTRIAL BRAKE CONTROLS
NoRoL
TACHOGRAPH (Recording Speedometer)
TRANSFORMERS

ARMY E NAVY

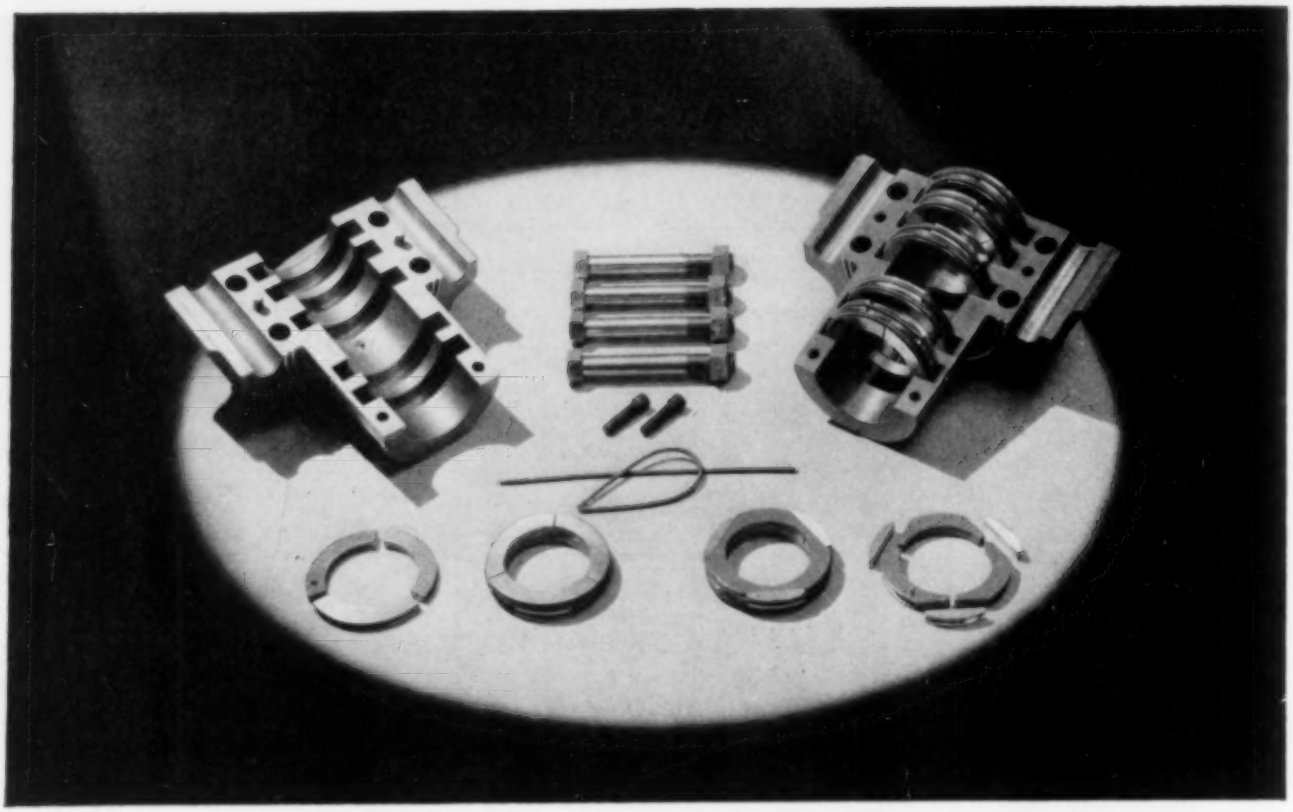
Wagner Electric Corporation

ESTABLISHED 1891

6418 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS

Wagner squirrel-cage motors discussed in this advertisement are but four motors built by Wagner. There are other types of polyphase motors, and several types of single-phase and direct-current motors making up the Wagner line. No matter what your requirements may be, there's a Wagner motor ideally suited for the job.



SPLIT CASE TYPE PRECISION METALLIC ROD PACKINGS

YOUR engine or compressor will deliver more horsepower at less cost if its rods are equipped with COOK'S Metallic Packings. And the reasons why are summed up in the following features of COOK'S Packings:

Precision construction assures positive seal of pressure . . . . Packing rings "float" in self-contained casings which allows for rod misalignment and vibration, avoiding the extra friction and wear that would otherwise result. . . . Packing rings are made of anti-friction metals and designed to compensate for wear automatically. . . . Design also provides a constant oil film between packing rings and rod, eliminating metal to metal friction.

COOK'S Packings reduce friction to a mere fraction, become a permanent part of the machine and render years of service without repairs.

Recognizing these advantages many engine and compressor manufacturers supply COOK'S Packings as original equipment; others furnish them on request. There is a proved COOK'S Packing for all prevailing pressures and temperatures in annular cup, split case and other special designs. Here is illustrated a split case packing developed for application without disconnecting the rod.

When ordering new equipment specify COOK'S Metallic Packings. For equipment in service, write us direct or our nearest office.

Sealing Pressures Since 1888

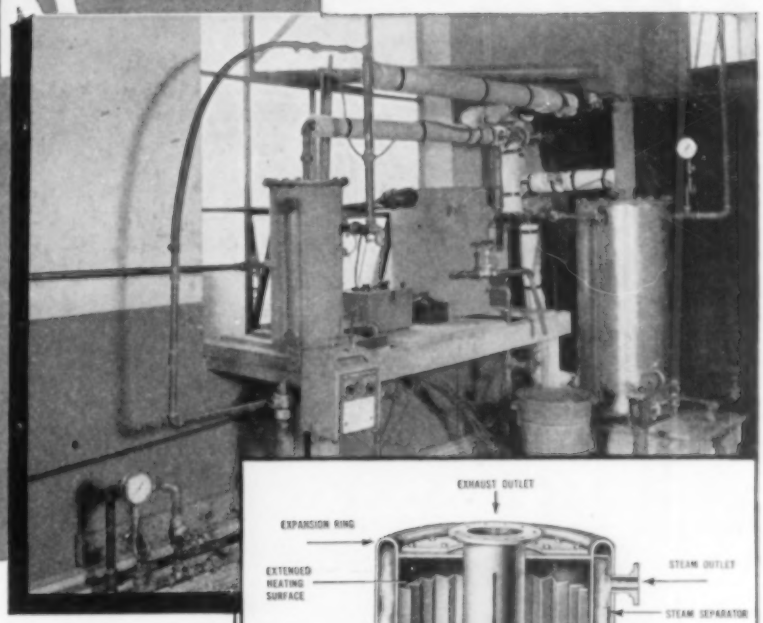
C. LEE COOK MANUFACTURING CO. INCORPORATED

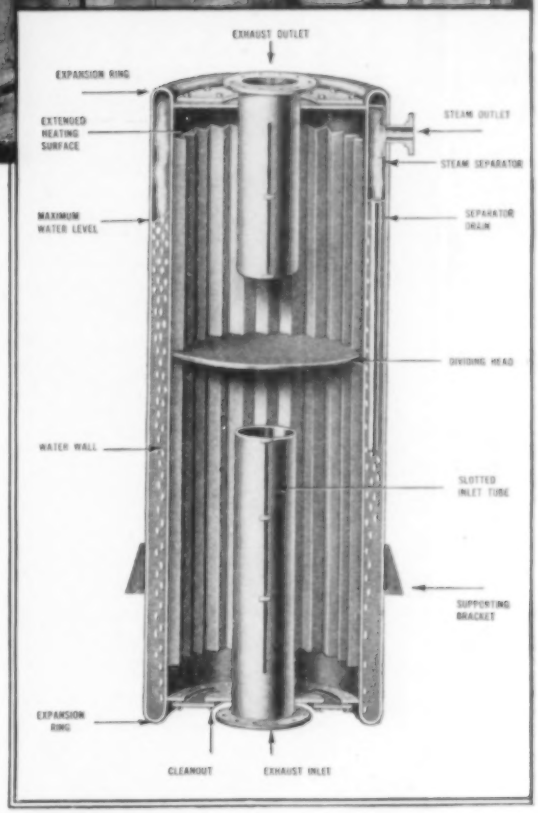
LOUISVILLE, KY.

BALTIMORE • BOSTON • CHICAGO • CLEVELAND • HOUSTON • LOS ANGELES • MOBILE • NEW ORLEANS • NEW YORK • SAN FRANCISCO • TULSA

PUT EXHAUST HEAT TO WORK

WITH MAXIM HEAT RECOVERY SILENCERS



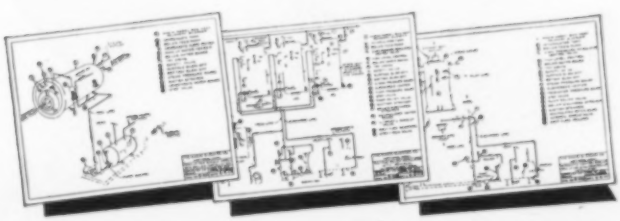


The illustration above shows a test hook-up for Heat Recovery Silencer research in the Maxim Research Department. Here again, as in Maxim Silencers, the basis for superior performance is constant and painstaking research which results in proper basic design and a never ending search for improvement.

Maxim Heat Recovery Silencers provide effective silencing of exhaust noise, 100% spark arresting (where this is desired) and the recovery of waste exhaust heat to produce steam or hot water for heating or processing operations.

These Heat Recovery Silencers are available with automatic controls which control steaming rate by varying water level in the water wall of the Silencer. They may be run wet or dry. Highly efficient heat transfer is assured by the Maxim extended heating surface feature.

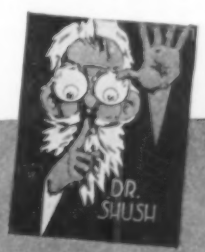
For silencing without the heat recovery feature, Maxim makes silencers for internal combustion engine exhaust or intake, steam engine exhaust, air compressor intake, vacuum pump discharge, blower intake and discharge, high velocity steam, air or gas discharge. Engine exhaust silencers available with or without spark arrestor. Bulletins on request.



PRACTICAL WORKING HOOK-UPS

Typical Heat Recovery Silencer hook-ups are available with a detailed discussion of each. We will be glad to send them to you. Just ask for Dwgs. B-298, B-301, B-302 and B-303.

THE MAXIM SILENCER CO. • 85 HOMESTEAD AVE., HARTFORD, CONN.

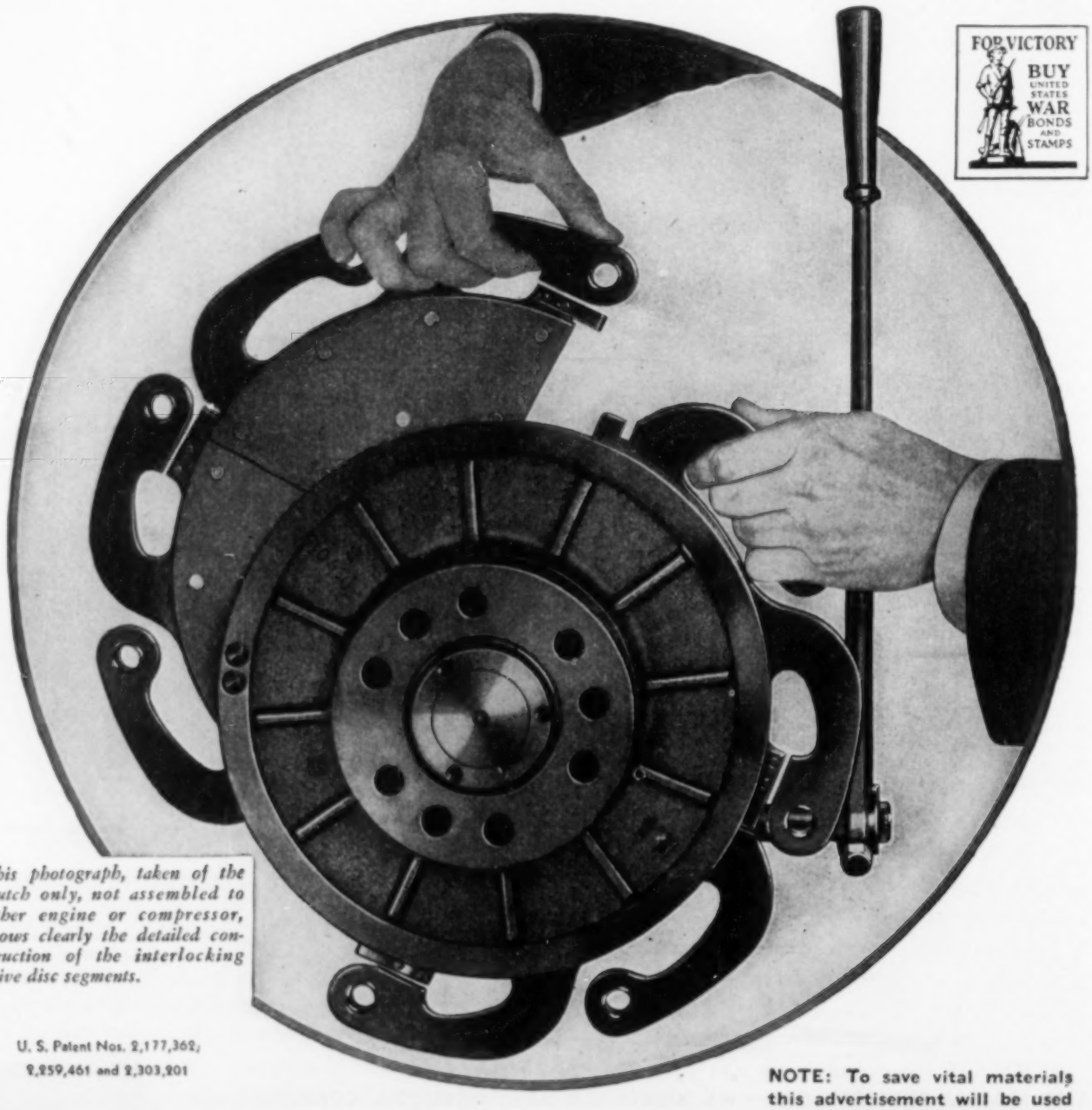


ARMY E NAVY

MAXIM

FLEX-DISC CLUTCHES

Used on the entire line of I-R *Mobil-Air* Compressors, have a time proven drive disc with flexible fingers solidly bolted to the fly wheel. When the friction facings become worn these drive discs, which are quickly detachable in segments, may be removed and relined or replaced without disconnecting the engine from the compressor.



FOR VICTORY BUY UNITED STATES WAR BONDS AND STAMPS

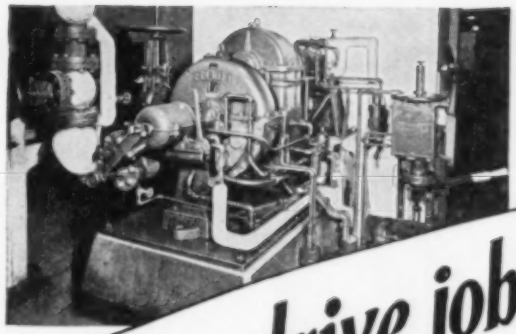
This photograph, taken of the clutch only, not assembled to either engine or compressor, shows clearly the detailed construction of the interlocking drive disc segments.

U. S. Patent Nos. 2,177,362; 2,259,461 and 2,303,201

NOTE: To save vital materials this advertisement will be used for "the duration."

C. M. EASON, INDUSTRIAL CLUTCH CO.

Waukesha Wisconsin

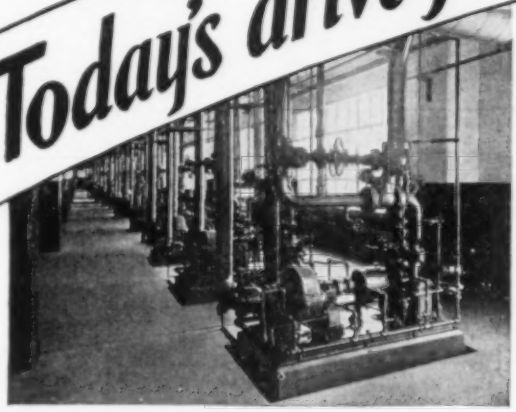


Elliott turbine with built-in gear driving an induced draft fan in the steam generating plant of a large aircraft manufacturer.

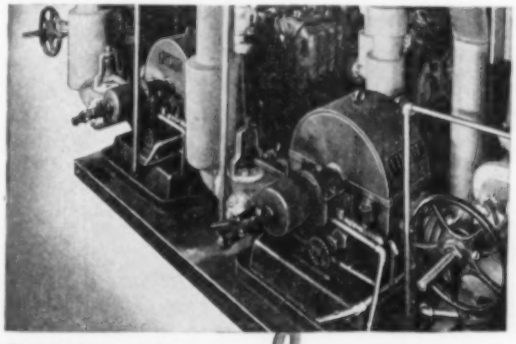
Today's drive jobs demand dependable

ELLIOTT

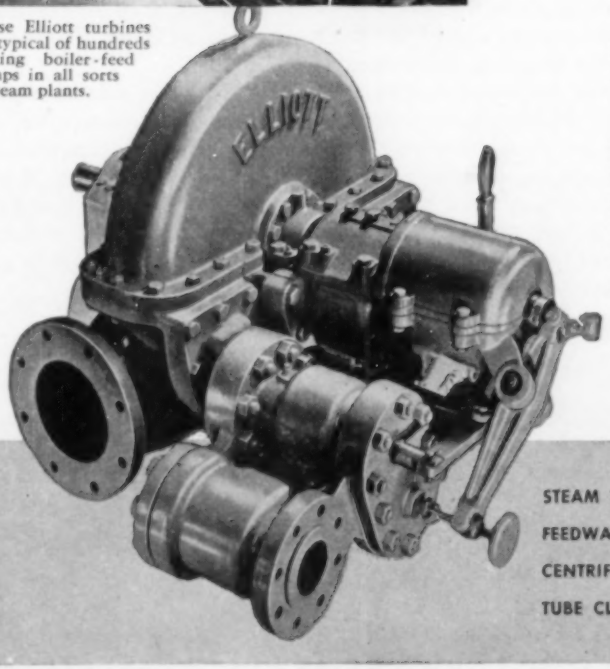
TURBINES



A long line of Elliott turbines direct-connected to pumps in a high-octane gasoline refinery.



These Elliott turbines are typical of hundreds driving boiler-feed pumps in all sorts of steam plants.



Drive reliability is essential today more than ever before. 24-hour service is usual. Units *must* stay on the line. And in many plants there are no standby units due to war curtailment.

Elliott turbines by the hundreds are living up to their high reputation on non-stop jobs in production of critical war needs such as high-octane gasoline, magnesium, synthetic rubber, etc. These units are heavy, substantial, rugged. At the same time they have every refinement and safety feature that exceptional service demands.

Construction details are covered in descriptive bulletins, on request. If you have a specific drive job, an Elliott turbine engineer will be glad to discuss it with you.

ELLIOTT COMPANY

Steam Turbine Dept., JEANNETTE, PA.

DISTRICT OFFICES IN PRINCIPAL CITIES

H-688

STEAM TURBINES • GENERATORS • MOTORS • CONDENSERS
FEEDWATER HEATERS AND DEAERATORS • STEAM JET EJECTORS
CENTRIFUGAL BLOWERS • TURBOCHARGERS FOR DIESEL ENGINES
TUBE CLEANERS • STRAINERS • DESUPERHEATERS • FILTERS

JOBS LIKE THESE done easier and faster with

"Cushioned-Air" Paving Breakers

Have you considered the variety of work you can do with Paving Breakers? Here are some applications that will save you time, money and manpower:

Paving Breakers tear up asphalt, wood, or stone paving; break out concrete or shale in trenching for gas and water mains, sewers, electric cables and service lines. They are handy for railway track work, for tamping backfill, for breaking asphalt floors in warehouses, etc.

You can use them to knock out walls, floors, and foundations of concrete, brick or stone when demolishing buildings. They are ideal for breaking rocks that are too large for grizzlies or crushers.

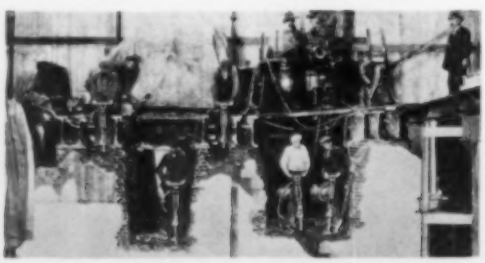
Paving Breakers are also powerful and light enough for use in breaking clinkers in gas passages and tuyeres; smashing slag; taking out slag pockets; breaking skulls in ladles and hot pots; punching blasting holes in slag piles; tearing out old furnace and converter linings; tamping furnaces; smashing flue dust or clinker sows, etc.

When blasting is impossible because of surrounding machinery or buildings, the foundations of compressors, engines, pumps, machine tools, etc., are broken with Paving Breakers into pieces that can be conveniently handled. In some cases, holes are drilled with "Jackhamers" and the concrete broken with feather and wedge, the wedges being driven with Paving Breakers.

A paper mill's records show that one man with a Paving Breaker can break worn sulphite digester linings as fast as 18 men working by hand. These tools are also widely used for breaking pulpstones, etc.

By merely changing the fronthead parts, a paving breaker can be used to drive 2", 2½" or 3" wooden sheet piling for ditches, shafts, manholes, and other excavations. Front-heads also available for driving spikes, form pins, etc.

"Cushioned-Air" Paving Breakers are best for all of these jobs. An air cushion prevents the piston from hitting the fronthead. There is less shock on the wearing parts, less breakage, and less upkeep. Thus the "Cushioned-Air" feature increases the life of Ingersoll-Rand Paving Breakers. It is your assurance of dependability and efficiency.



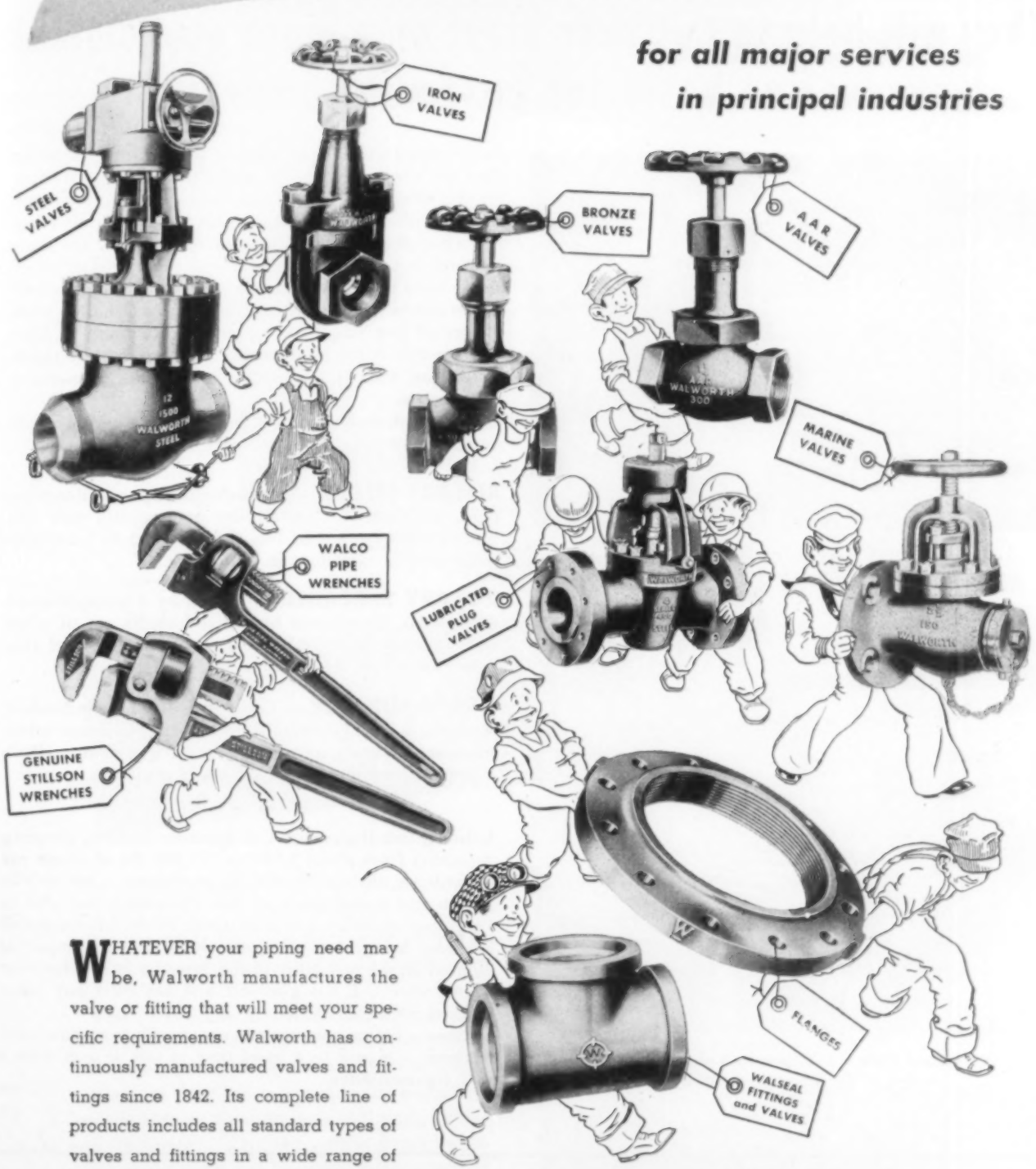
5-571

COMPRESSORS • TURBO BLOWERS **Ingersoll-Rand** ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

11 BROADWAY, NEW YORK 4, N. Y.

WALWORTH VALVES and FITTINGS

for all major services in principal industries



WHATEVER your piping need may be, Walworth manufactures the valve or fitting that will meet your specific requirements. Walworth has continuously manufactured valves and fittings since 1842. Its complete line of products includes all standard types of valves and fittings in a wide range of styles, sizes, and materials. For a detailed description of Walworth products, write on your company letterhead for a free copy of Walworth Catalog 42.

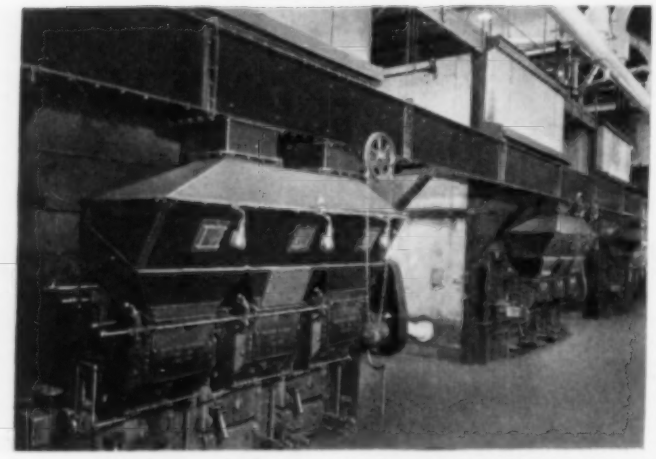
12 AWARDS TO 4 PLANTS

WALWORTH
valves AND fittings
60 East 42d Street, New York 17, N. Y.

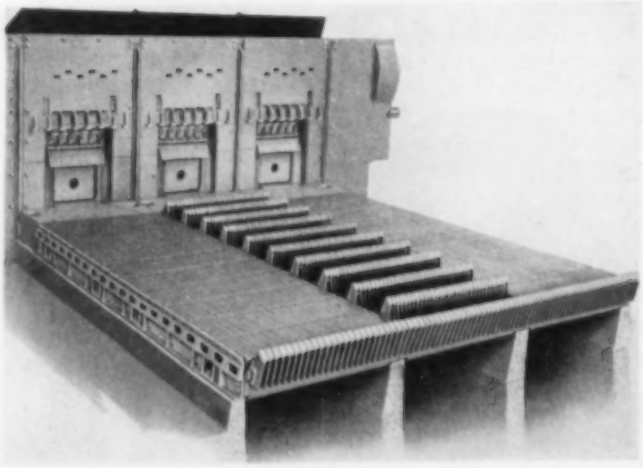
DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

C-E Spreader Stokers REDUCE Steam Costs!

They will help to put your plant on a more economical production basis for post-war competition



Installation of three C-E Spreader Stokers firing three C-E Steam Generators, Type VU.



Rear View of C-E Spreader Stoker with one section of the grates in dumping position.

Every manufacturer who expects to operate at a profit after the war recognizes the necessity of putting his plant on the most efficient and economical production basis to cope with the tough competition that will surely come . . . when peace returns. In many cases one of the most resultful steps in that direction will be the reduction of steam costs through the application of a C-E Spreader Stoker. Its reasonable first cost, its ability to handle a wide variety of low cost coal, its sensitive response to load changes and its low maintenance combine to make steam generation with the Spreader Stoker both economical and efficient.

Its many desirable features, embodied in a well balanced design that is rugged and compact, include:

ROTARY FEEDER – A non-clogging, non-avalanching type which handles wet or dry coal equally well and insures a steady flow of fuel through a 15 to 1 capacity range despite variations in coal sizing.

ROTARY SPREADER – Driven by a variable-speed mechanism. Distributor blades and shafts are of alloy steel to resist wear and corrosion. Adjustable fuel tray aids proper fuel distribution on the grate.

GRATE SURFACE – Composed of small individual flat-surface castings, permitting easy replacement when necessary. Separate control of air to each grate zone. Both stationary and dumping type grates available.

• • • •

Existing installations of C-E Spreader Stokers, covering capacities from about 5,000 to 175,000 lbs of steam per hr, indicate the breadth of C-E's experience – not only in design and manufacture of this equipment, but also in its proper application so as to insure *all* the advantages of spreader firing. And you can rely on C-E for impartial counsel on the suitability of the Spreader Stoker for your plant, since C-E has available and can offer any other type of industrial stoker.

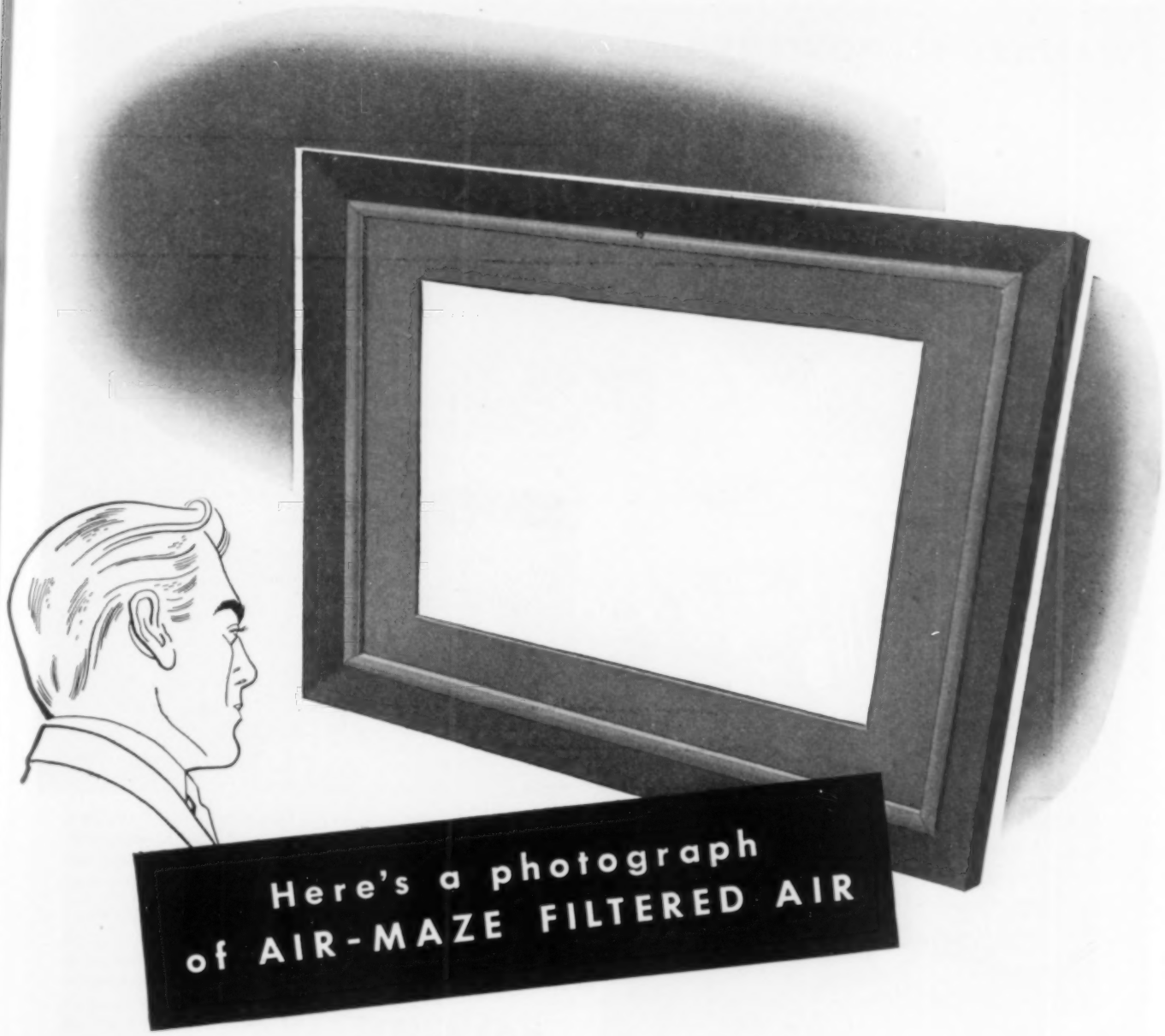
Now – before you are confronted with peacetime competition – would be a good time to talk it over with a C-E representative.

A-866

COMBUSTION ENGINEERING

200 MADISON AVENUE **NEW YORK 16, N. Y.**

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS



The air that passes through an Air-Maze filter is really clean . . . freed from the dirt, dust, grit and foreign particles that wear out equipment, impair health, and cause discomfort and costly damage.

The protection that clean air affords has been a contribution of Air-Maze engineers and manufacturers for 20 years. The effectiveness of their job is found in the successful installations in thousands of buildings, hotels and factories . . . in the range canopies in restaurants, ships and hospitals everywhere . . . and on engines and compressors in all types of service.

If you have a problem involving air, ask your nearby Air-Maze representative or write us direct for Catalog No. AGC-144.

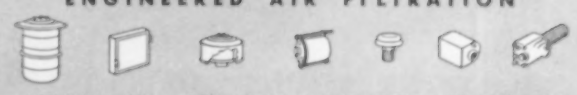
AIR-MAZE CORP. • CLEVELAND 5, OHIO

Representatives in principal cities. In Canada: Williams and Wilson, Ltd., Montreal, Quebec, Toronto, Windsor; Fleck Bros. Ltd., Vancouver, B. C.

IF IT USES AIR . . . USE

AIR-MAZE

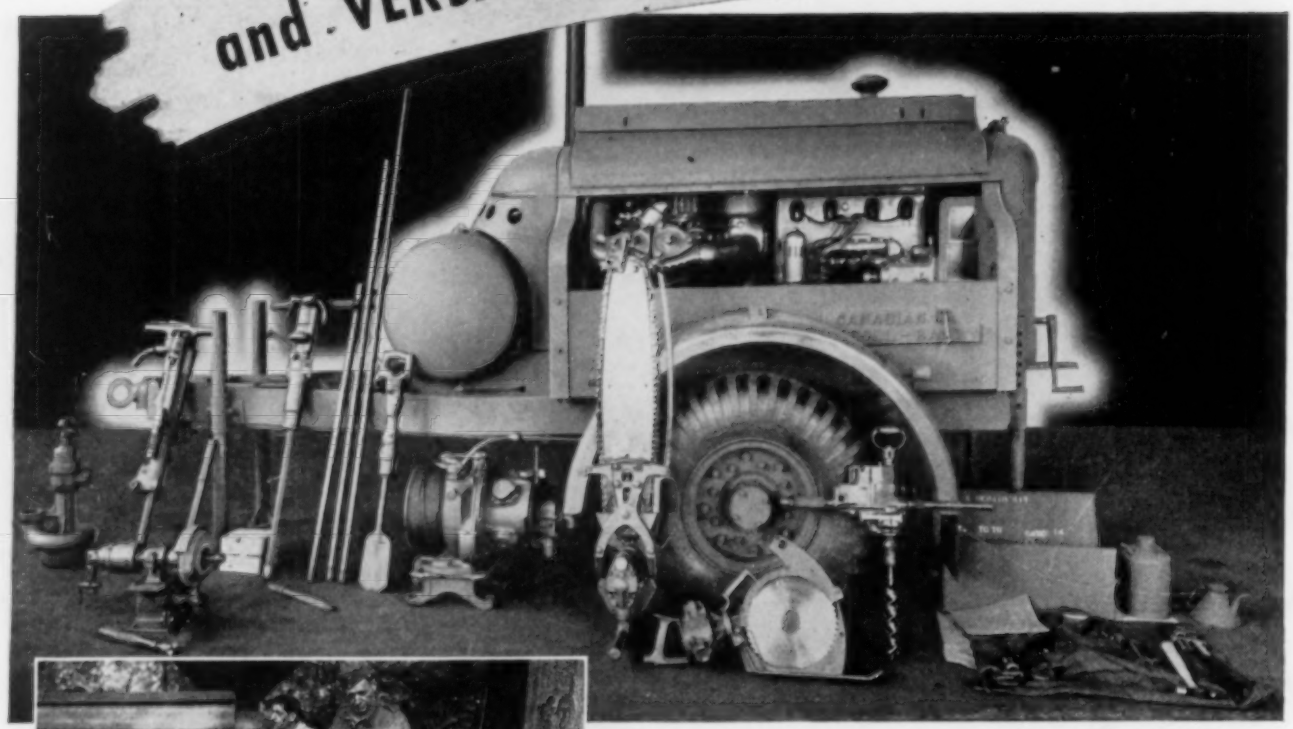
ENGINEERED AIR FILTRATION

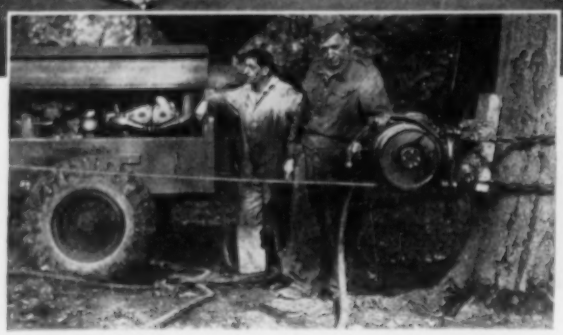


• Oil bath type filters and filter-silencers • Cleanable filter panels for air-borne dirt, oil, grease and liquids • Oil-wetted type filters and filter-silencers • Exhaust spark arresters • Gear case, crankcase and tank vent breathers • Oil-separators for engine crankcases • Full-flow type cleanable oil filters

WAUKESHA-POWERED

AIR TOOLS for MOBILITY and VERSATILITY on all fronts...





Air tool used by Royal Canadian Engineers—a Waukesha Engine powered Canadian Ingersoll-Rand Portable Air Compressor, complete with auxiliary equipment including chain saw for felling trees, power hand saw for heavy timber construction, air operated auger, grinding stand and sump pump.

●

Making repairs at battle front—Royal Canadian Engineers using an air hoist, mounted on tree trunk, to pull a drag scraper.

Overseas Photo Courtesy of Department of National Defense (Canada)

Compressed air is "ammunition" for the front-line Royal Canadian Engineers who repair damaged bridges and construct new ones, build roads, landing fields and advanced bases. *Waukesha-powered* Canadian Ingersoll-Rand Portable Air Compressors give their pneumatic tools the mobility and versatility so vital to battle-winning efficiency.

The Waukesha Engine and the compressor are joined in a single unified assembly—for complete reliability. All the advantages of multi-cylinder power—quicker acceleration, clean combustion, cool valves and fuel economy with more power—are built into this compact, sturdy, 4-cylinder Waukesha Engine.

Until victory, every Waukesha is a war-work engine. Then there'll be Waukesha Engines . . . gas, gasoline, or diesel fuel . . . for shovels, cranes, hoists, pavers, mixers, graders, surfacers, tractors or any peacetime industrial power machinery. Consult Waukesha now about your own future engine needs.

Get Bulletin 1377

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS.

NEW YORK • TULSA • LOS ANGELES

MORE POWER FOR VICTORY

WAUKESHA ENGINES

EXCELLENCE OF THE PRODUCT
REFLECTS EXCELLENCE OF THE PROCESS

MADISON-KIPP LUBRICATORS

Madison - Kipp Lubricators provide the most dependable method of lubrication ever developed. There are six popular models for every application. Illustrated is the Model OL, standard eight feed ratchet drive. Madison-Kipp specializes in lubricators for original Standard equipment. Write for special engineering data for your particular requirement.

Fresh Oil **FED UNDER PRESSURE BY THE MEASURED DROP**

MADISON-KIPP DIE CASTINGS

These castings are made by the Madison-Kipp Die Casting Process and are parts used in the assembly of the Madison - Kipp OL Lubricator above. The Madison-Kipp Die Casting Process offers the product designer almost unlimited opportunities to add pleasing appearance, light weight and improved strength at an over-all cost saving. Address all inquiries to our offices at Madison, Wisconsin.

MADISON-KIPP CORPORATION
202 WAUBESA STREET
Madison 4, Wis., U. S. A.
Sole Agent in England
Wm. Coulthard & Son
Ltd. Carlisle

THAT EXTRA OUTPUT..

Wartime performance has proved the ability of Bucyrus-Erie quarry and mine excavators to deliver the EXTRA output required to meet emergency demands successfully. Like every machine in the complete line, the 2½-yard 54-B Ward-Leonard electric delivers "years ahead" performance because it is scientifically designed for the work it must do. At the right are seven of the features behind the big output owners everywhere are getting with the 54-B.

BUCYRUS-ERIE 54-B 2½ YD. ELECTRIC

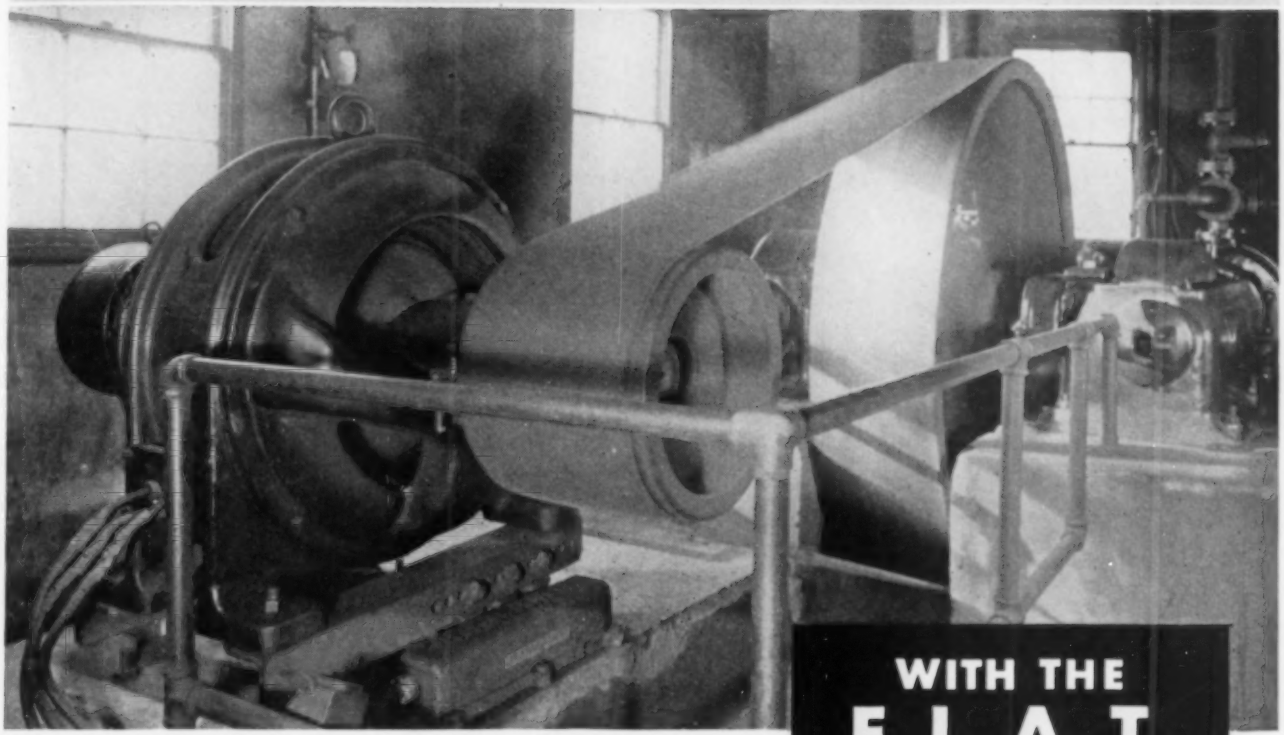
1. POWERFUL DIGGING ACTION — Long, effective upper boom section gives wide digging angle, efficient application of digging force.
2. FAST SWING — Swing motor has low moment of inertia for quick acceleration or deceleration. Full Ward-Leonard control saves seconds every cycle.
3. EASY, ACCURATE CONTROL — Easy working master switches control all digging functions. Convenient levers control propel, boom hoist, steering, etc.
4. SMOOTH PERFORMANCE — Anti-friction bearings and gears running in oil ensure long-lived smoothness of power flow. Direct drive means smooth reversing service.
5. LOW OPERATING COSTS — Balanced design and sturdy construction result in greatest strength per pound of weight.
6. FULL MOBILITY — The 54-B mounting stands up to years of tough pit travel. Flexible steering, hydraulically controlled, permits sharp or gradual turns.
7. SIMPLE CONVERTIBILITY — The 54-B can be quickly converted from shovel to dragline in the field.

BUCYRUS ERIE

South Milwaukee, Wisconsin

2145

SAVE space, power and replacement costs



WITH THE F. L. A. T. DRIVE

The **Flat Leather Automatic Tension** drive with Graton & Knight **"Research"** leather belting offers many advantages to compressor users.

AUTOMATIC TENSION

While it is necessary in most drives to increase the belt tension to accommodate short centers, in the **F. L. A. T.** drive the tension is automatically adjusted to match the load. Guesswork has been eliminated.

SHORTER CENTERS

The pivoted base permits smaller arc of contact on the driving pulley, thus reducing necessary center distance between motor and compressor pulleys.

LONG LIFE

A **"Research"** belt on the **F. L. A. T.** drive will outlast a rubber V-belt by 2 to 1. Full details are given in Leather Belting Manual. Write Graton & Knight Company, 365 Franklin St., Worcester 4, Mass.

The drive illustrated above shows a 100 H. P., 900 R. P. M. motor driving a two stage Ingersoll-Rand Compressor, Type XCB. The motor is mounted on a #14 Rockwood base. Motor pulley 19½"; compressor pulley 72"; center distance 79". In this drive an idler was formerly used, causing excessive belt wear. G & K engineers recommended the pivoted base and **"Research"** 12" heavy double leather belt. Higher power transmission resulted, due to the pulley grip and minimum stretch of **"Research"**. This is only one example of the efficiency of **"Research"** in power transmission.

GRATON AND KNIGHT

Research Leather Belting

The most complete line . . . manufactured under one control from green hide to finished product.
Graton & Knight distributors are listed under "Graton & Knight" in "Belting" section of Classified Telephone Directory and THOMAS' REGISTER.

A SPECK OF STEEL LODGED IN AN EYE . . . CAN COST MORE THAN A DIAMOND

Valueless in itself, this speck of steel became costly in the split second it took to cause an eye accident. The final bill was $343.00.*

An adequate eye-protection program demands a place in every *cost reduction* program. And, because American Optical Safety Goggles are light, cool, comfortable and easy-to-wear, their protection is now readily accepted by workers in every field of industry.

Ask your Safety Director to consult with an A. O. Safety Representative. There is an American Optical Branch Office in every large industrial center.

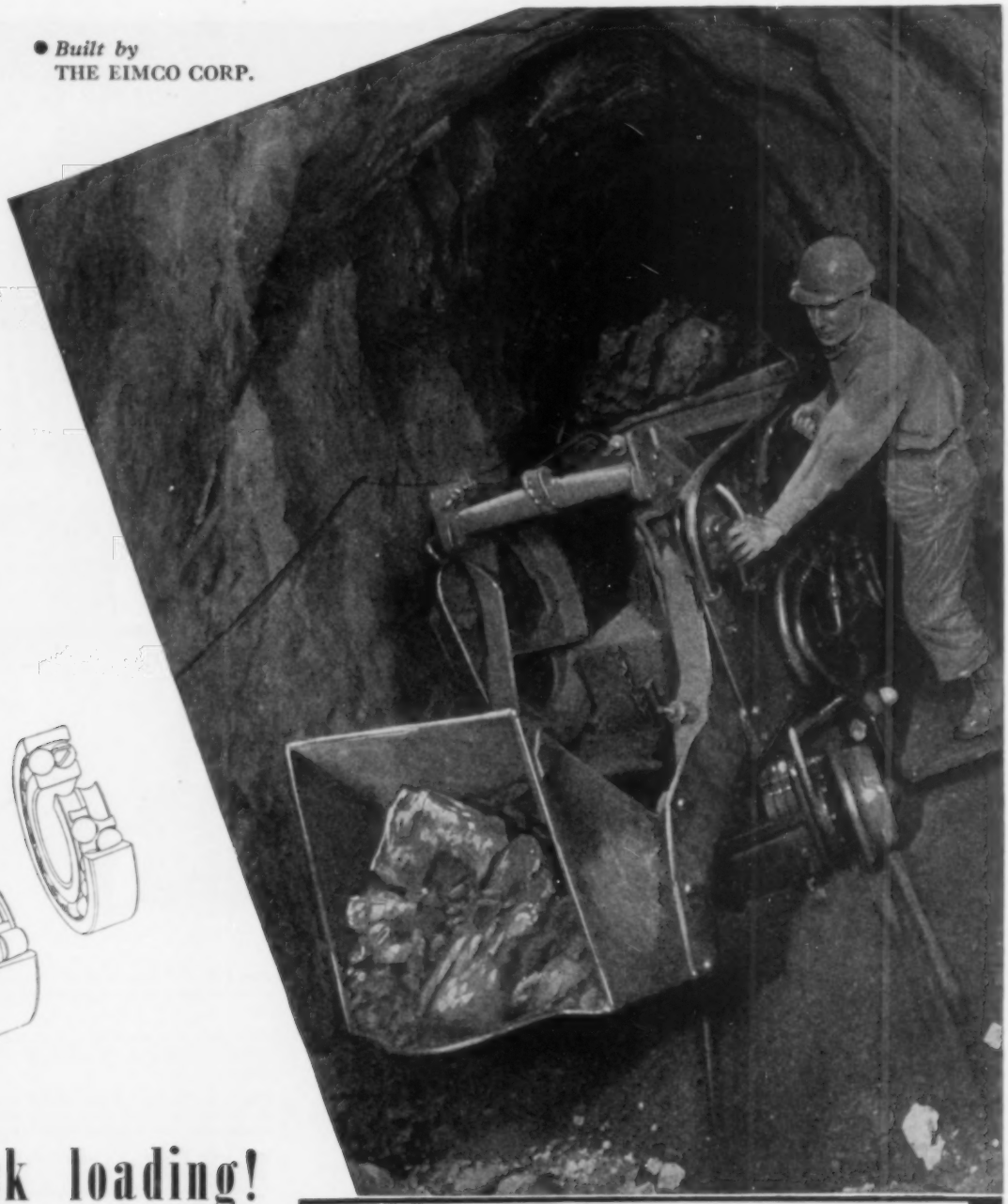
*Average cost of compensation and medical treatment for eye accidents, according to insurance company figures.

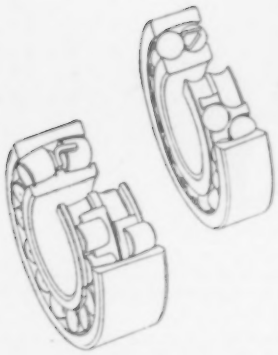
American Optical

COMPANY

SOUTHBRIDGE, MASSACHUSETTS

● *Built by*
THE EIMCO CORP.





For quick loading!

Many mining men easily recall the good work of Model 21 Eimco-Finlay Loaders in operation at face of the 32,000 ft. Carlton Tunnel. These 81 cu. ft. cars were often filled in less than three minutes, and complete 8 ½-foot rounds were loaded in as little as 55 minutes. That SKF Bearings are on their vital rotating parts is only natural. For years The Eimco Corporation has depended upon SKF's for high bearing capacity that's available at all times . . . for freedom from constant underground servicing . . . for year after year of smooth, reliable performance. By using SKF's on the machines it makes, The Eimco Corporation is giving its customers the bearings that they, too, can depend upon.

5717

SKF INDUSTRIES, INC., PHILA. 34, PA.

SPECIFY

SKF

BEARINGS

Powell Valves
comin' through

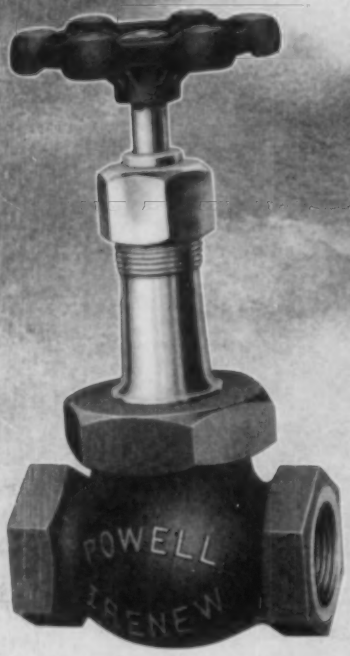
Every day thousands of valves of all types, designs and materials are "comin' through" the various stages that make the name "Powell" on a valve the hallmark of quality. Into every step—from perfect casting to final merciless testing—goes the KNOW-HOW of 99 years of concentration on making valves—and valves only—for industry.

When they are finally pronounced worthy in every detail to bear the Powell name, they go out to join the hundreds of thousands of their family who are "comin' through" with flying colors under all kinds of service conditions in every branch of American industry.

1708

158

150



190

Fig. 158—150-pound Bronze Lift Check Valve with screwed ends, screwed cap and renewable vulcanized composition disc.

Fig. 150—150-pound Bronze Globe Valve with screwed ends, union bonnet and renewable vulcanized composition disc.

Fig. 190—150-pound Iron Body Bronze Mounted Globe Valve with screwed ends, union bonnet and regrindable, renewable wear-resisting nickle bronze seat and disc.

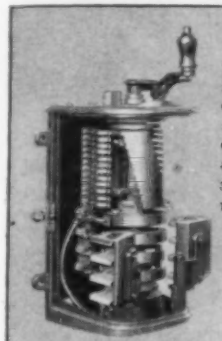
Fig. 1708—200-pound Bronze Globe Valve with screwed ends, union bonnet, renewable seat and regrindable, renewable wear-resisting nickle bronze semi-cone plug type disc.

The Wm. Powell Co., Cincinnati 22, Ohio

POWELL VALVES

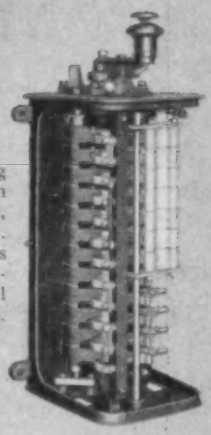
Motor Starters EVERY TYPE,

EVERY SIZE, FOR EVERY MACHINE APPLICATION



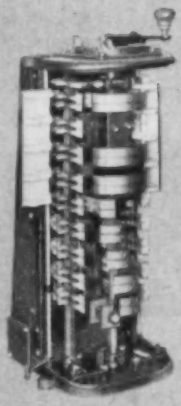
D-C DRUM SWITCH

For use with reversible or nonreversible d-c motors. Recommended where frequent motor starting and stopping and speed adjustment are necessary.



A-C DRUM SWITCH

Suitable for starting or reversing service on small cranes, hoists, machine tools, etc. These drum switches (with primary resistance) will control squirrel-cage motors.

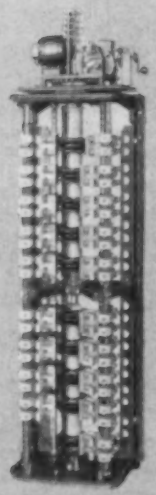


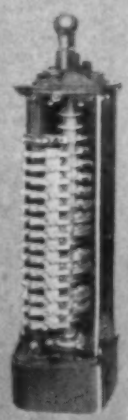
A-C REVERSING DRUM SWITCH

For severe duty controlling large wound-rotor induction motors which operate cranes, hoists, bending rolls, etc.

MOTOR-OPERATED, A-C DRUM SWITCH

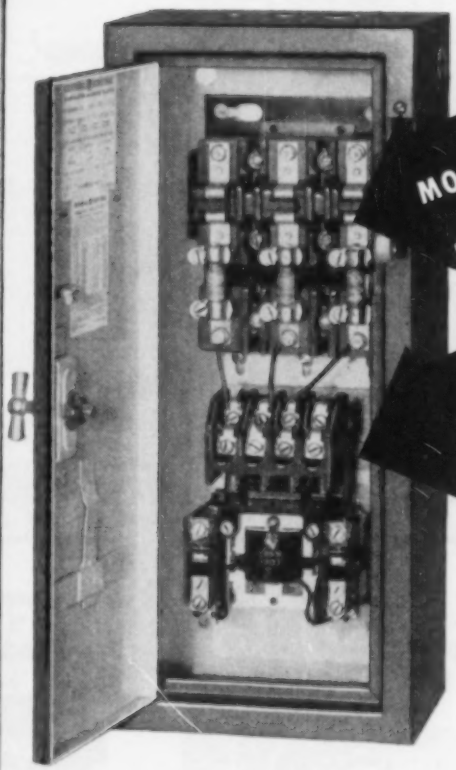
Designed either for remote operation or as an automatic control when used with a pilot-circuit device.





DRUM SWITCH FOR SMALL A-C MOTORS

Recommended for starting or reversing small wound-rotor motors—provides dependable operation.



COMBINATION STARTER

6 Ways You Save by Using Combination Starters

1. ***50% reduction in mounting time***—You mount only one device, not two.
2. ***40% reduction in wiring time***—Connect to only 9 terminals, not 15.
3. ***Save ordering time***—Instead of buying two devices, you buy one factory co-ordinated unit.
4. ***Conserve man power***—By eliminating one complete mounting job on every installation.
5. ***Saving of wall space***—The one device takes less space than two.
6. ***Save critical materials***—Combination starters require less wire and steel conduit than separately mounted devices.

WHAT IS YOUR APPLICATION?

G-E starters come in a variety of enclosures to meet any operating conditions. May we send you additional information? *General Electric Company, Schenectady 5, N. Y.*

Buy all the BONDS you can—and keep all you buy

GENERAL ELECTRIC

976-138CL-6910

There's Extra Service in Every Length of "SUBWAY" Air Hose

One of the oldest and best-known brands in the Goodall quality line. All-Synplastic construction, with tube, cover and carcass built to give long, reliable service on every job requiring heavy-duty air hose, above ground or below. Made in sizes ½" to 1¼", inclusive. Specify "SUBWAY" Brand, Style D-154.

Contact Our Nearest Branch or Main Office for Details

GOODALL on the Job LONGER!

GOODALL

RUBBER COMPANY INCORPORATED

The Goodall-Whitehead Companies

Philadelphia. Trenton. New York. Chicago. Pittsburgh. Boston.

GOODALL RUBBER CO. of CALIF. Factory - Trenton, N. J.

GOODALL RUBBER CO. of TEXAS Established 1870

BALANCED FLYWHEEL-FAN

another "PLUS FEATURE" IN ALL WISCONSIN Air-Cooled ENGINES

Every Wisconsin Air-Cooled Engine is equipped with a high-efficiency fan that is cast integrally with the flywheel. And each of these flywheel-fans is carefully balanced on a combination balancing and boring machine which accurately locates the heavy spots by means of gravity pendulum swing . . . and then takes out the excess metal, as required. Each unit is tested for smooth, free-running balance.

Just another production detail that removes a potential source of vibration and needless wear . . . *right at the source!* Isn't that the kind of an engine you want on your equipment?

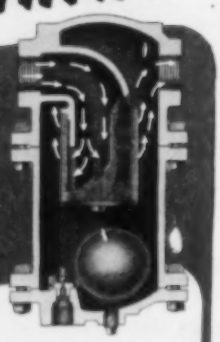
Most H.P. per pound

WISCONSIN MOTOR Corporation

MILWAUKEE 14, WISCONSIN, U. S. A.

World's Largest Builders of Heavy-Duty Air-Cooled Engines

SELF DRAINING



Today's newest idea in SEPARATOR DESIGN . . .

● With this new Johnson Type "SA" Separator there's no need for external traps—no more bother and uncertainty of manual draining. It has a complete trap mechanism built right in—drains itself automatically whenever necessary.

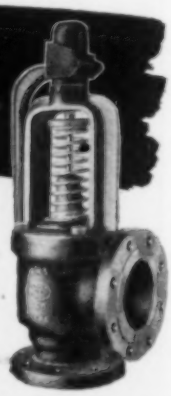
Like all Johnson Separators it removes more than 99% of all moisture and dirt from compressed air or steam. It can be teamed up with the Johnson Aftercooler where moisture has been vaporized by heat of compression, or with the Johnson Oil Absorber where every trace of oil must be removed.

Johnson Separation Devices come in sizes, styles for all needs. Write for new bulletin.

THE Johnson Corporation

830 WOOD STREET, THREE RIVERS, MICHIGAN

VENTURI DESIGN— *added* SAFETY



This FARRIS Venturi Safety Valve No. 2150 develops extra high lift for HI-Capacity discharge . . . on HI-Pressure, HI-Temperature work. "Precision Alignment" secures minimum blow-down for economical plant operation. "Separator Bell" for added boiler-room safety.

All finished surfaces precision machined. Pops accurately, dependably—for the protection of your equipment. Built for long-life-operation without maintenance expense. Just one of the complete line of FARRIS Safety and Relief Valves.

Write today for our Bulletin.

Built in steel and semi-steel for pressures to 600 lbs. at 750°F. Sizes ¾" to 6" x 8". Meets ASME requirements.

FARRIS ENGINEERING CO., 354 Commercial Ave., Palisades Park, N. J.

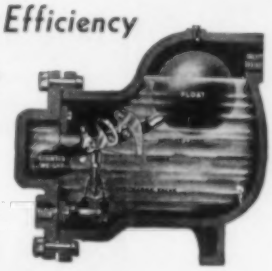
Farris

SAFETY and RELIEF VALVES

2 *Dependable Units to Help You*

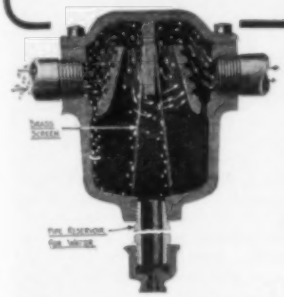
KEEP AIR LINES CLEAR

and Increase Efficiency



NICHOLSON
COMPRESSED AIR TRAP

Model "JR", right, provides long, trouble-free service. For pressures to 200 lbs. Intermittent discharge; welded stainless steel float; water-sealed discharge valve.



NICHOLSON
AIR SEPARATORS

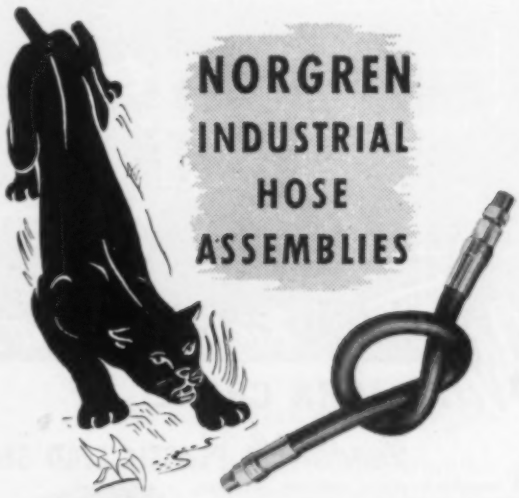
Removes moisture, oil and grit; supplies clean, dry air to pneumatic tools, greatly prolonging their life. Ingenious baffle and 4-layer filter of fine-mesh brass screen, easily removed for cleaning. Inlet and outlet tapped for ¼", ⅜", ½", ¾" connections.

Write for Catalog 444 or See Our Catalog in Sweet's

W. H. NICHOLSON & CO.

180 OREGON ST., WILKES-BARRE, PA.

Valves • Traps • Steam Specialties



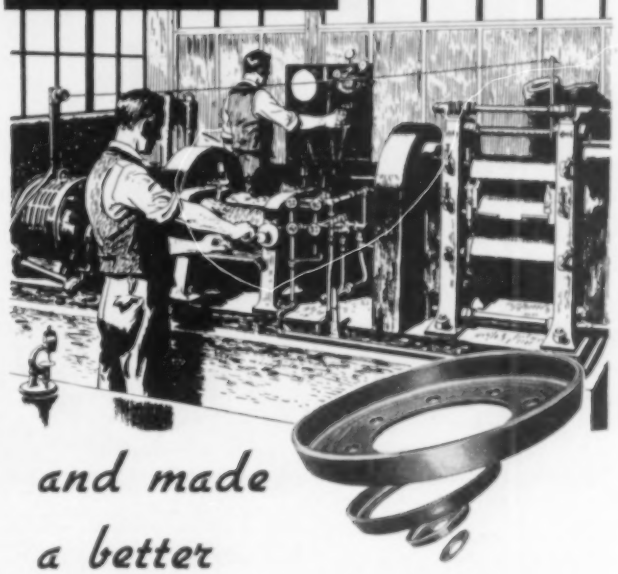
Dependable carriers of high or low, pneumatic or hydraulic pressures. Built tough and flexible, highly resistant to heat, cold, grease, solvent and vibration. Permanent couplings for high pressures and reusable couplings for low pressures.

Write for new bulletin No. 450. C. A. Norgren Co., 220 Santa Fe Drive, Denver 9, Colorado.

Limber as a Lariat
STRONG as Steel

Norgren

They taught Oil and Rubber to get along



and made a better

PISTON PACKING CUP

THE wide range of service conditions that piston packing cups must meet in industry calls for something special in service qualities. Wabco packing *has* these qualities—thanks to Westinghouse research.

Various materials were investigated in an extended search for the best packing material. Rubber had the greatest promise, but it couldn't stand oil. The Research Department kept digging, and finally came up with a formula that could live with lubricants and still retain its resilience, mechanical strength and sealing properties under severe service conditions.

In addition to these service qualities, Wabco packing offers an important exclusive mechanical feature. Built-in limited compression, available in cups from 1-inch to 7½-inch, assures low friction.

Wabco packing cups are available in sizes from ¾-inch to 30-inch, for original installation in pneumatic cylinders; from $1\frac{3}{16}$-inch to 7-inch for hydraulic cylinders. If your product includes such cylinders, you will find Wabco cups an economical, simple, and dependable solution of your packing problems.

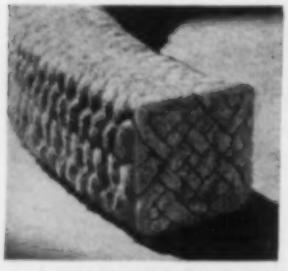
Westinghouse Air Brake Co.
Industrial Division - - - Wilmerding, Pa.

Primitive pump used on an Italian farm during the 17th Century—from a copper engraving by Athanasius Kircher, 1601-1680. Illustration from Bettmann Archive.

Primitive Pump—1650

The lift pump used by the farmers in Europe some four hundred years ago seemed to do a fairly good job according to this old-time illustration. But it's a far cry from the modern high-pressure and high-speed pumps in use today.

Pump valves, packings, gaskets and oil seals have also improved through the years—keeping pace with engineering advancements in the equipment in which they are used. Today the complete line of Garlock products fills every need of modern industry.

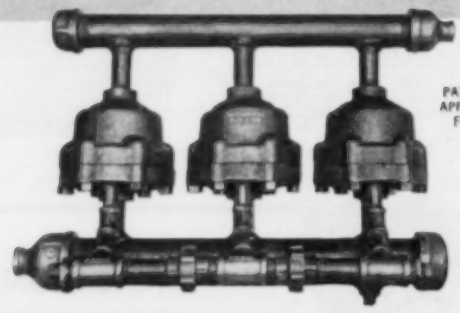


GARLOCK LATTICE-BRAID PACKING
The unique structural design imparts semi-automatic pressure action. Available in several styles for service on pumps and other equipment.

THE GARLOCK PACKING CO.
PALMYRA, NEW YORK
In Canada: The Garlock Packing Co., of Canada, Ltd., Montreal, Que.

Garlock

Purify Any Pressures, Air or Gas, with Bird-White Multiple Unit *Pur-O-fier*



PATENT APPLIED FOR

Three Models Available

Model A-1 furnished with a 1 inch turbo-rotor and will accommodate volumes from 1 to 8 cubic feet.

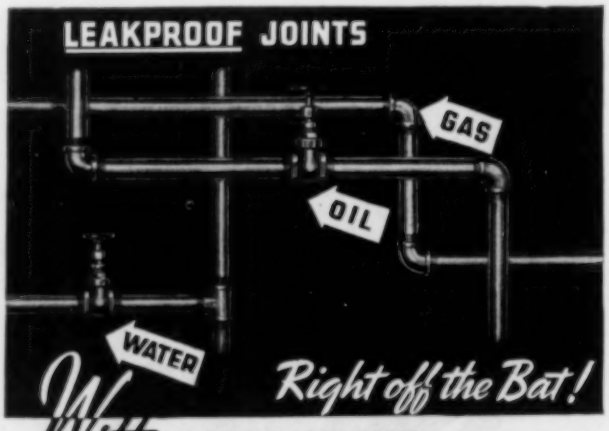
Model A-2 has a 2 inch turbo-rotor and can accommodate volumes from 10 to 35 cubic feet.

Model A-4 has a 4 inch turbo-rotor and can accommodate volumes from 35 to 100 cubic feet.

Bird-White multiple unit Pur-O-fiers save time and money by protecting air-operated machines, gauges and controls from contamination. They give positive purification to air or gas lines regardless of fluctuating pressures or high volumes.

The perfectly balanced Turbo-Rotor purifying action makes them sensitive to both regular and intermittent pressures. Write for Bulletin 10 giving complete details.

BIRD-WHITE COMPANY
Dept. CA, 3119 WEST LAKE STREET
CHICAGO 12, ILLINOIS



With JOHN CRANE *Insoluble* PLASTIC LEAD SEAL

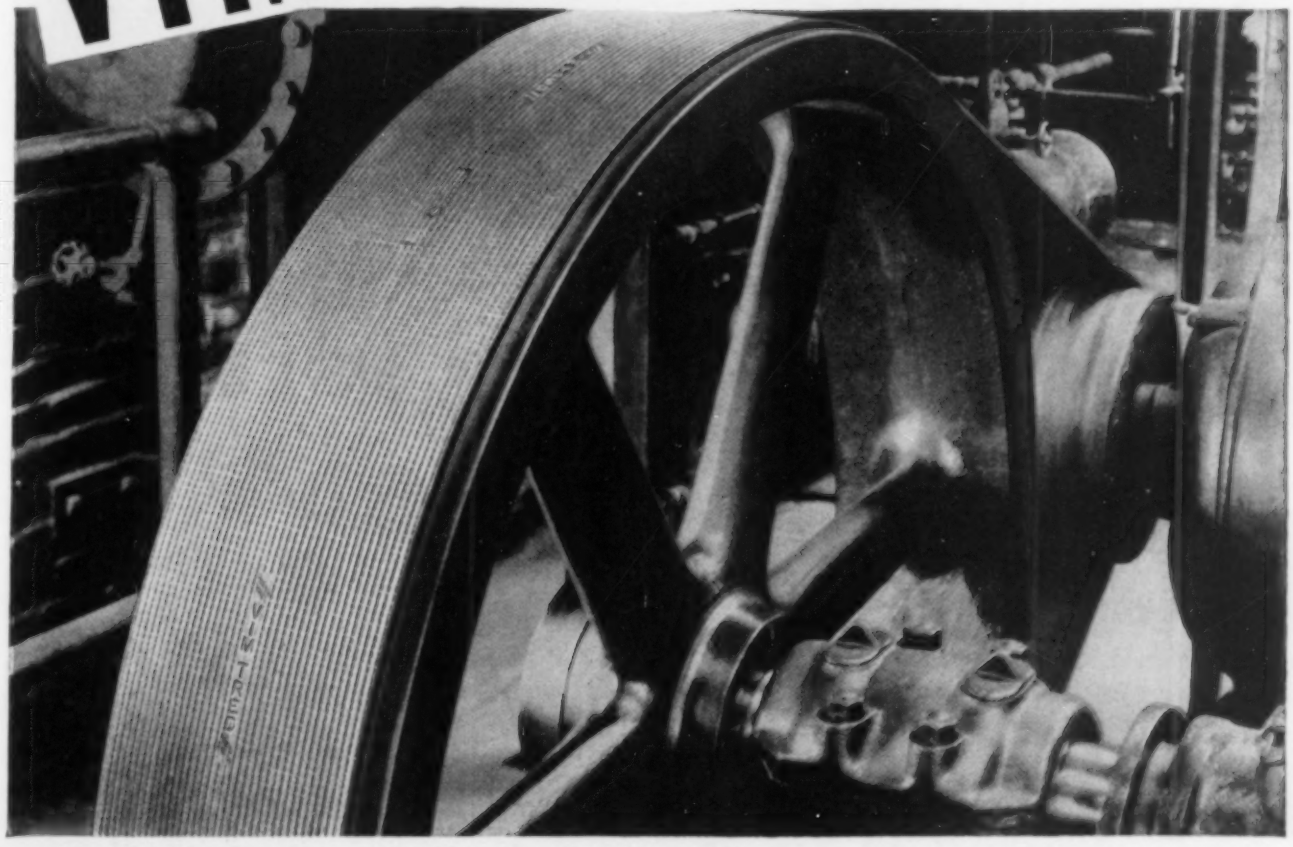
- *Insoluble* in water, gasoline, propane, CO^2, etc. Won't wash out.
- *Seals quickly;* fills clearances and imperfections.
- *Stops galling, rust.* Never hardens; joints easily taken apart later.
- *Ready for use,* in 1, 5, 7-lb. cans.

Order a trial can of Plastic Lead Seal—watch it reduce maintenance in your plant or product.

CRANE PACKING COMPANY 1808 CUYLER AVE. • CHICAGO 13, ILL.

FOR COMPRESSORS—

VIM TRED LEATHER BELTING



You can identify VIM TRED the instant you see it, because of the distinctive "more grip—less slip" tread, an exclusive patented feature.

This tread is but one reason why VIM is a "natural" for tough compressor drives. Others: resiliency, flexibility, durability, uniformity.

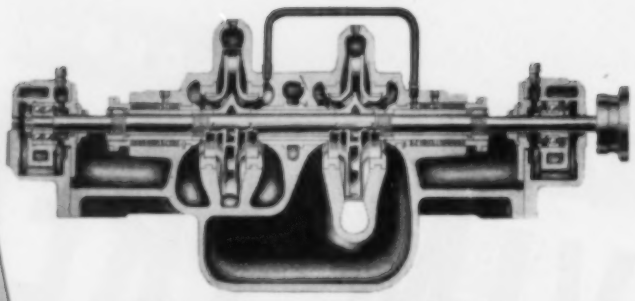
Big words, yes, but Houghton's VIM is a *big* belt in every sense.

Put it on a pivoted motor base to maintain proper tension automatically, and you have the finest compressor drive money can buy. Now's the time to check such drives in your plant for full delivery of power. Can we help? E. F. HOUGHTON & CO., Philadelphia and all principal cities.

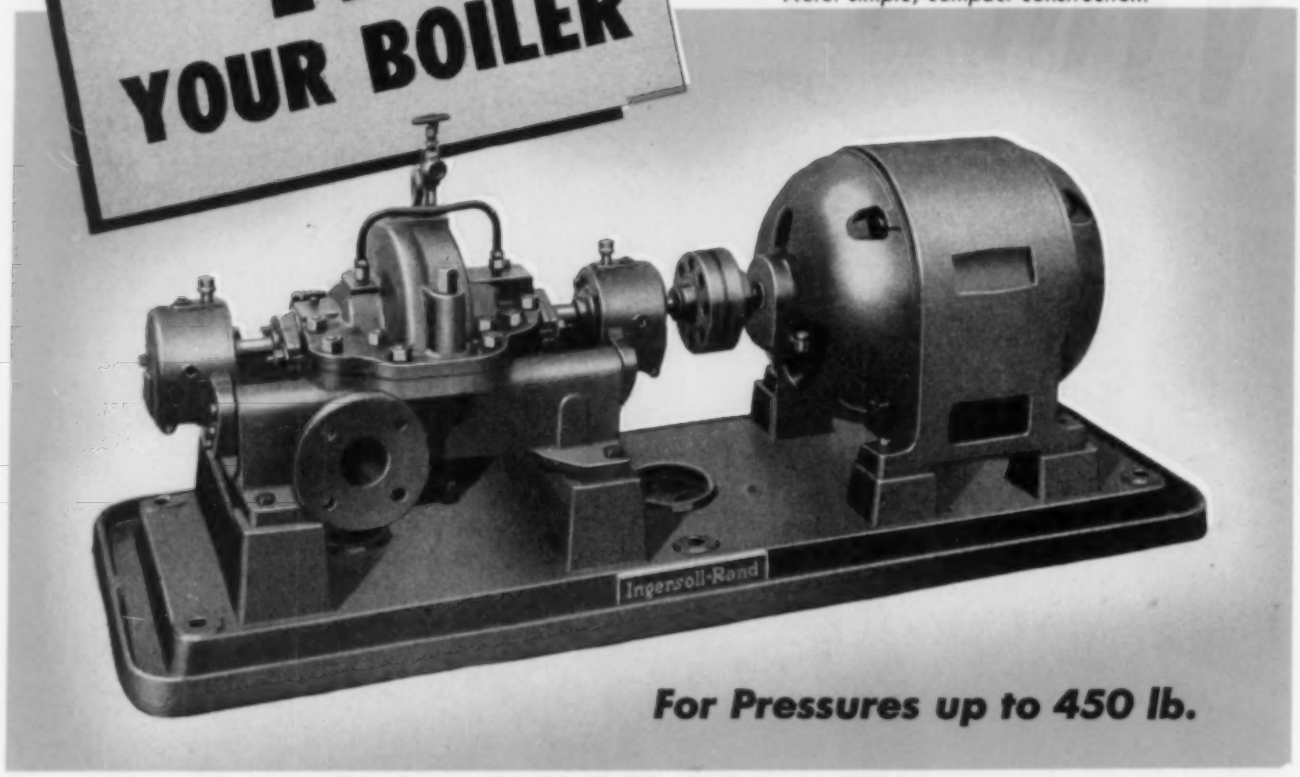
HOUGHTON'S

Treaded LEATHER BELTING

MADE TO fit YOUR BOILER



Note: simple, compact construction.



For Pressures up to 450 lb.

Hundreds of industrial boilers requiring feed pressures up to 450 pounds per sq. in. are fed by Ingersoll-Rand Class GT pumps. Recent improvements in materials and design, such as new casings and oversize oil-lubricated ball bearings made these pumps even better boiler-feeders.

Sturdy two-stage pumps—they are available in sizes to match the capacity of a wide range of boiler units. Different combinations of materials, selected by the I-R metallurgical department, provide long-life service with any boiler-feed water.

If your boiler plant requires a feed pump in the range of these GT units, up to 1500 gal per min, you can't find a more dependable pump. If your boiler plant requires a larger or a smaller feed pump, there is an equally efficient and dependable unit in the *complete* Ingersoll-Rand boiler-feed line. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York 4, N. Y.

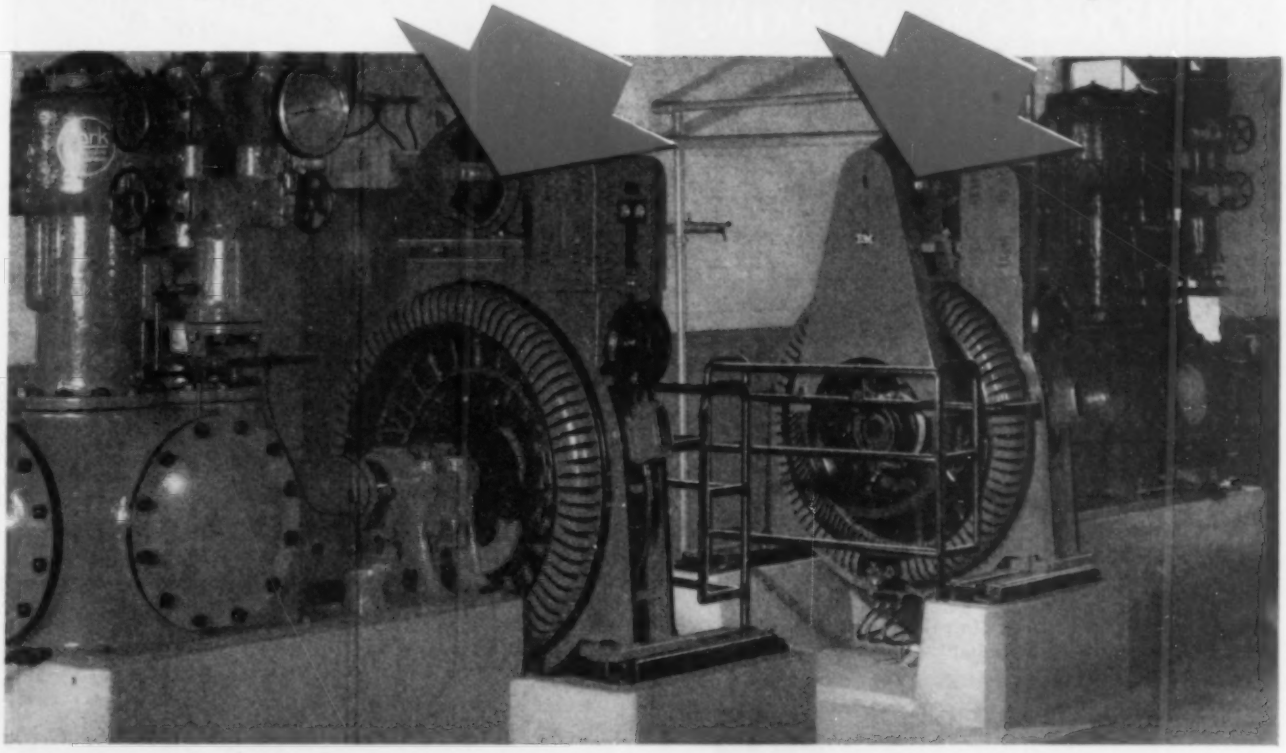
Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

10-634

COMPRESSORS • AIR TOOLS • ROCK DRILLS • TURBO BLOWERS • CONDENSERS • CENTRIFUGAL PUMPS • OIL AND GAS ENGINES

See why RAILWAYS ICE COMPANY SAYS: "Performance has been perfect"



E-M "*Packaged*" SYNCHRONOUS MOTORS

drive refrigeration compressors to keep carloads of cold chow chilly!

AT their Topeka plant, the Railways Ice Company have operated two synchronous motor-driven ammonia compressors for 5½ years, ten months out of the year, producing 122 tons a day. Increased demands for ice, plus a continuous flow of Government and Army foodstuffs through their low temperature freezer departments, put these synchronous motor-driven compressors to a real test.

And proof that these E-M motors have done a good job, vital in protecting war-time foodstuffs, is Railways Ice Company's enthusiastic report: "*Motor performance has been perfect.*"

The compact arrangement of motor, exciter and control in an easy-to-use "package" offers many advantages for refrigeration compressor drives. Simple installation, use of minimum floor space, and reduced first cost are some of the reasons for specifying E-M "packaged" Synchronous Motors on *your* next job. *Write today for Publication 153.*

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

Polarized
FIELD FREQUENCY CONTROL

Field control for "Packaged" Synchronous Motors uses the simple, reliable *E-M Polarized Field-Frequency Control System.* Field excitation is applied at the correct motor speed and rotor angle to give most powerful synchronizing and minimum starting current. It also automatically removes excitation should the motor pull out of step due to overload or power disturbance. This permits motor to resynchronize when normal conditions are restored.

E-M

A2015 REG. U.S. PAT. OFF. SPECIALISTS IN SYNCHRONOUS MOTORS AND MOTOR CONTROL

IS YOUR COMPRESSOR WORKING AT "PICK AND SHOVEL" EFFICIENCY?

Pick and shovel methods won't do the same jobs you expect from the modern Rock Drill, Stone Breaker or other pneumatic tool . . . that's why you can afford to make a heavy investment in highly efficient specialized compressor equipment.

But, from this investment in primary equipment, are you getting only "pick and shovel" efficiency when the rated pressure load isn't delivered all the way to your tools?

Why jeopardize thousands of dollars of investment by losing a good part of the power you are paying for because of faulty hose couplings and fittings? Costly pressure is too often blown away because of leaks . . . and never even noticed.

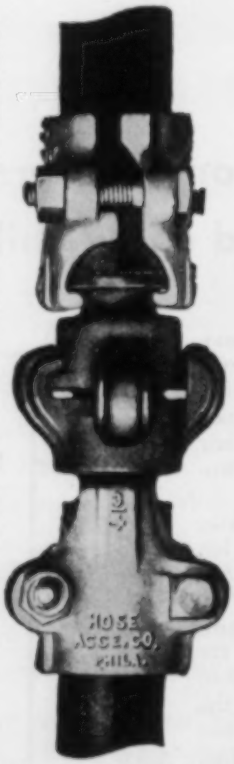
The answer is simple. To insure against leaks and costly breakdowns on your hose lines, demand LE-HI Hose Couplings for all pneumatic tool applications, pile driving equipment, low or high pressure air or steam applications and for discharge, suction or water hose service.

Your distributor knows the complete LE-HI Line, or write direct today.

Send for your copy of the new LE-HI Service Manual. Revised and enlarged to include many important facts that will aid you in obtaining better performance from your equipment. Write today for the LE-HI HOSE COUPLING HAND BOOK AND SERVICE MANUAL

Series 500 High Pressure Male Hose Coupling. The companion male unit for LE-HI Series 400. Adaptable to the widely diversified applications where the female units are used.

Series 400 High Pressure Female Hose Coupling. Will do the job wherever air, gases, water, steam or liquids are conveyed through hose. Used in every type of construction and industry.



Series 100 Universal Type Hose Coupling attached to hose with Series 10 Hose Clamps. Quickly and easily coupled or uncoupled . . . yet they lock securely. For compressed air lines and many special uses.

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LE-HI HIGH and LOW PRESSURE HOSE COUPLINGS

A DIVERSIFIED LINE FOR CONSTRUCTION AND INDUSTRIAL HOSE APPLICATIONS

Use BEARIUM METAL for all BEARING REQUIREMENTS

LASTS LONGER—PREVENTS BREAKDOWNS—SAVES MANY TIMES ITS COST

BEARIUM METAL is an amazingly different bearing bronze which performs with utmost satisfaction in any service involving rubbing friction. It will not seize—will not score—its advantages being particularly apparent under conditions considered prohibitive for ordinary bearing alloys.

BEARIUM METAL provides not only every desirable quality found in other bearing alloys, but possesses features in addition that are *exclusive*.

Full Information on Request

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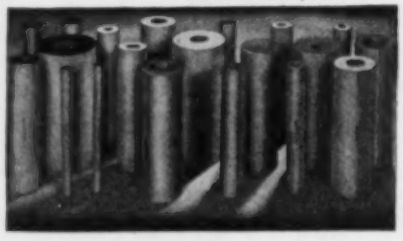
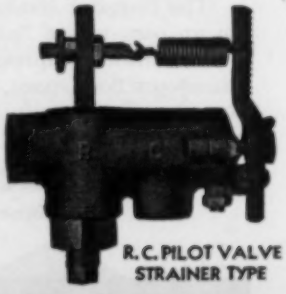


R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



R. C. PILOT VALVE STRAINER TYPE

R. CONRADER CO.

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PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

THIS IS THE MURPHY
AFTERCOOLER-SEPARATOR-FILTER
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GUARANTEED
YES...
Guaranteed, like all Murphy products, to do the job . . . and wear. Removes all moisture and oil from compressed air lines and delivers it to the point of use clean, cool and dry.
For complete description write for our A S F Bulletin.
Capacities
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GUARANTEED COMPRESSED AIR PRODUCTS
AFTERCOOLERS • SEPARATORS • STRAINERS • TRAPS
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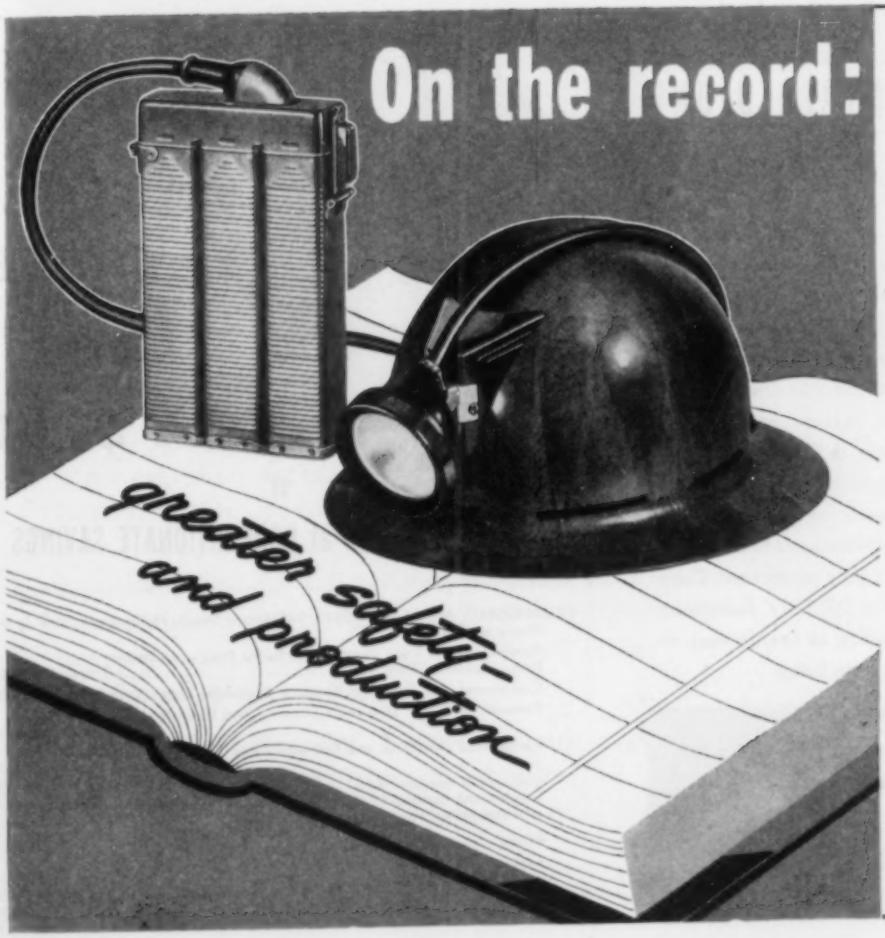
JAS. A. MURPHY & CO.
HAMILTON, OHIO, U.S.A.
Moisture Elimination Up To 3000 Pounds Per Square Inch



THE safety of better light provided by the Edison Electric Cap Lamp and the greater head protection of the M.S.A. Skullgard are serving men in mines of every type and size . . . the higher production at lower costs aided by this modern equipment are proved in the books of mining companies throughout the world. May we arrange a demonstration in your own operations?

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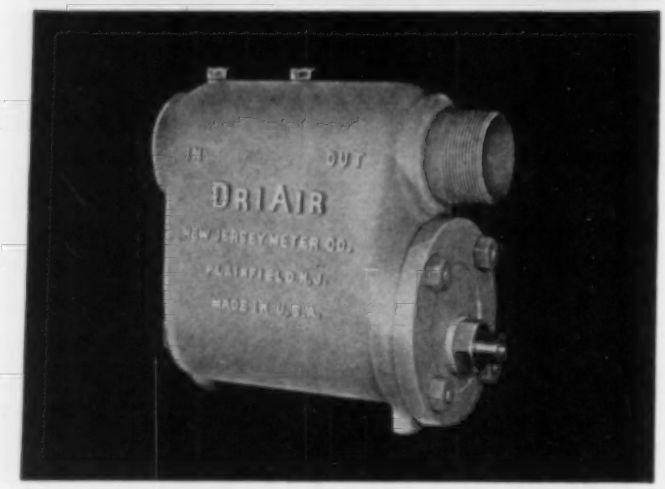

WHEN EQUIPMENT IS PROTECTED BY

DRIAIR

A COMPLETE SELF-CONTAINED UNIT

DriAir may be installed by suspending it from the piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

● The answer to many problems which arise in various applications of compressed air, DriAir speeds production by separating and automatically ejecting the condensed water and oil from the air. DriAir collects dirt and rust from the air lines and delivers clean dry air to the tools, thus reducing wear and prolonging their life. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent. Copy of Bulletin DA fully describing the operation of DriAir sent on request; write today.

NEW JERSEY METER COMPANY
PLAINFIELD, NEW JERSEY

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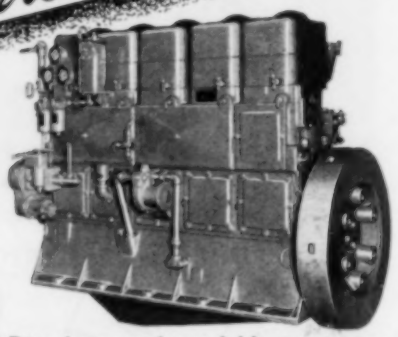

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30 to 600 H. P.

● Atlas Imperial Diesels mean dependable compressor power for they are field-tested . . . ready to go to work when delivered to your plant. Being slow-speed, low-firing-pressure engines that give top performance on any grade diesel fuel . . . without special lube oils . . . Atlas Imperials are lower over-all-cost power units. Large inspection doors and individual cylinder heads make servicing and maintenance simple and easy. Ruggedly built by a manufacturer with over forty years engine building experience, Atlas Imperial Diesels give more power for your dollar. Write for full details. State your H. P. requirement, we'll answer by return mail.

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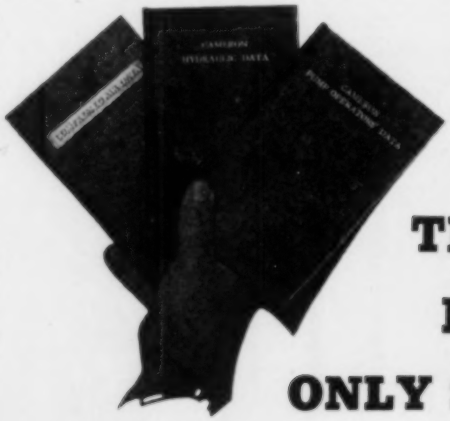
228 N. La Salle Street, Chicago 1, Ill., Room 1210
Branches in Principal Cities, Canada and Alaska



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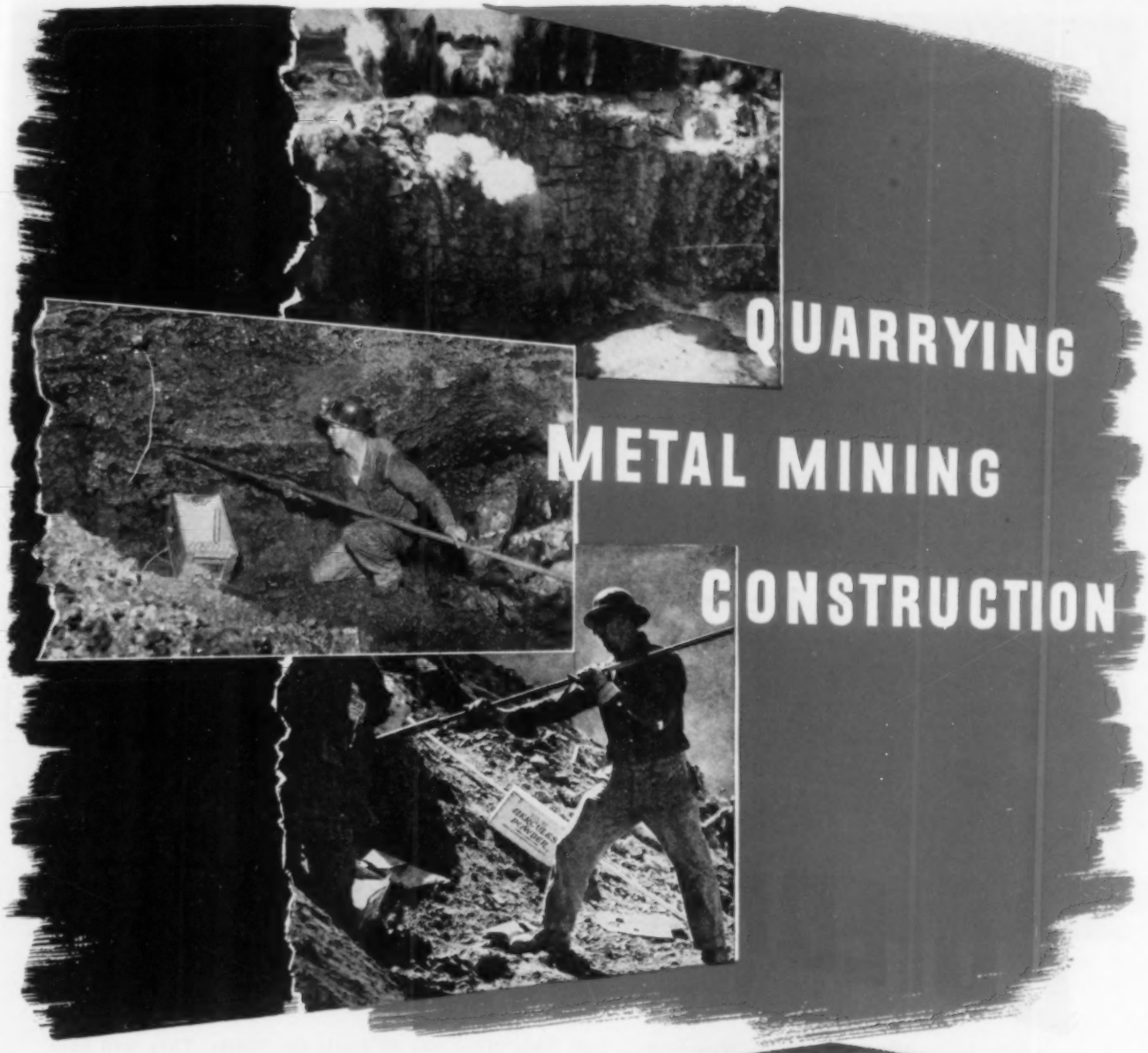

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XR-52

BUILDING...
tomorrow's wakening giant

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Controlling liquids and gases in miles-on-miles of tomorrow's piping will be thousands and thousands of Fairbanks Valves. They will have been selected because of topflight past performance . . . because architects and engineers know they can expect freedom from failure when a Fairbanks is installed.

Whether it's a small bronze valve or a huge iron body gate valve with a 24-inch opening the name Fairbanks stands for sound engineering, careful chemical and metallurgical control of alloys, ample metal for the job. The full line is given in catalog "42" which will be sent you if you ask for it. If you need special assistance with individual problems of valve selection and application, call on the facilities of the Fairbanks Engineering Department.

THE fairbanks COMPANY

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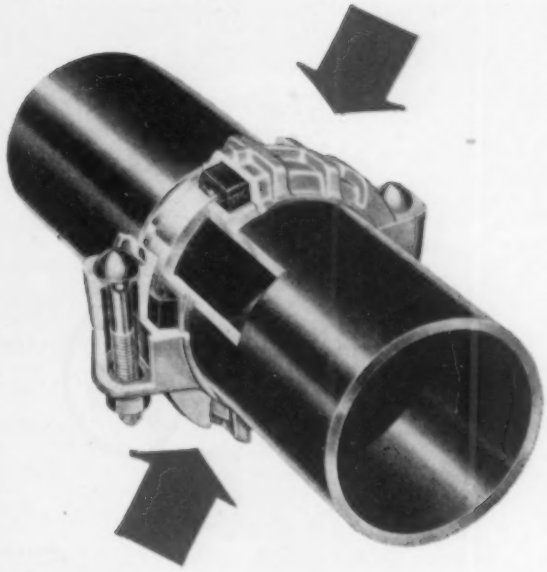
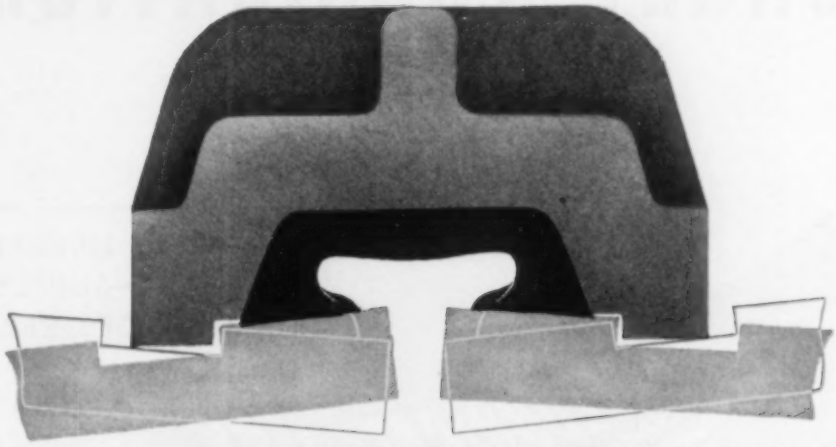


Victaulic Couplings will eliminate 'em . . .



Because of their *BUILT-IN* FLEXIBILITY!

WAR BONDS — A PIPE LINE FROM YOU TO HIM

HOW? . . . The key section of the housing floats in the pipe end groove with liberal but definite key and groove clearances. This eliminates the need for accurate and time-consuming alignment, and allows your pipeline to follow the contour of the ground with a minimum of bends and fittings.

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For full details of the economical and operating advantages of this leak-tight and mechanically-locked coupling write for our new illustrated Catalog and Engineering Manual . . . Address VICTAULIC COMPANY OF AMERICA, 30 Rockefeller Plaza, New York 20, N. Y. Other Victaulic offices—Victaulic Inc., 727 West 7th St., Los Angeles 14, California; Victaulic Co. of Canada, Ltd., 200 Bay St., Toronto.

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SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

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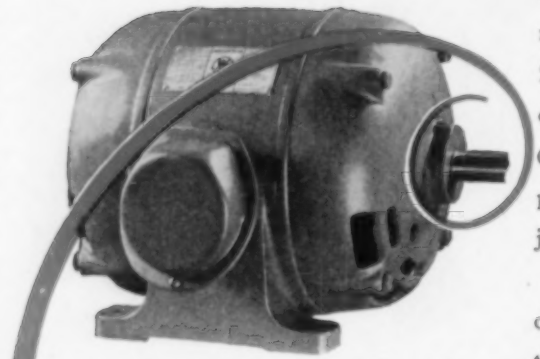
OIL MINING MARINE MUNICIPAL INDUSTRIAL

PRELUBRICATED SEALED BALL BEARINGS...NOW STANDARD ON TYPE CSP MOTORS UP TO 3 HP



Bought now, Westinghouse Type CSP Prelubricated Motors need no greasing till 1950! Extensively field tested in thousands of motor applications, the prelubricated ball bearings in Westinghouse Type CSP general-purpose motors have proved they can operate five years . . . 24 hours a day . . . without greasing. Overgreasing and consequent grease seepage into windings is eliminated. One of the major items of induction motor maintenance, periodic greasing, has been reduced to one grease packing job in five years.

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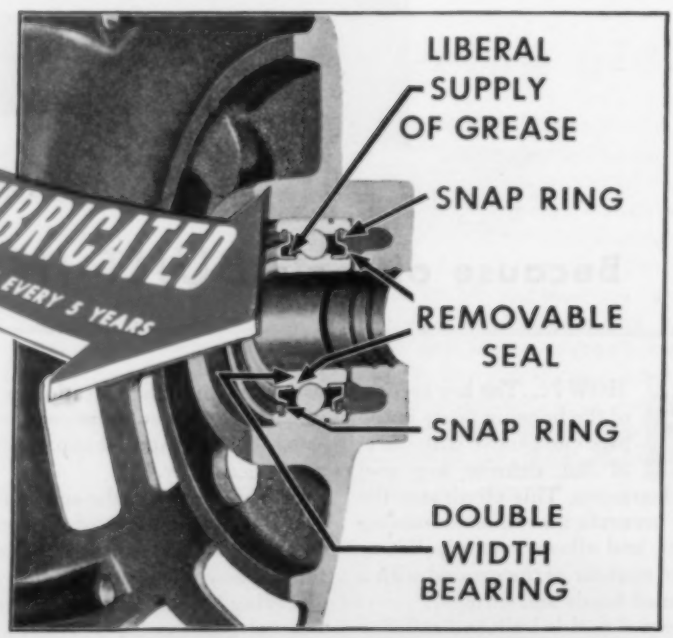
FORGET LUBRICATION...

till 1950!



ADVANTAGES OF WESTINGHOUSE TYPE CSP PRELUBRICATED MOTORS

- **Prelubricated Sealed Ball Bearings** reduce lubrication maintenance . . . assure longer grease life
- **Improved Tuffernell Insulation**
- **Dynamically Balanced Rotor**
- **Die-cast Rotor** with oversize fan
- **Liberal Through-ventilation**—air enters front, leaves at drive end of motor

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Type CSP Motors

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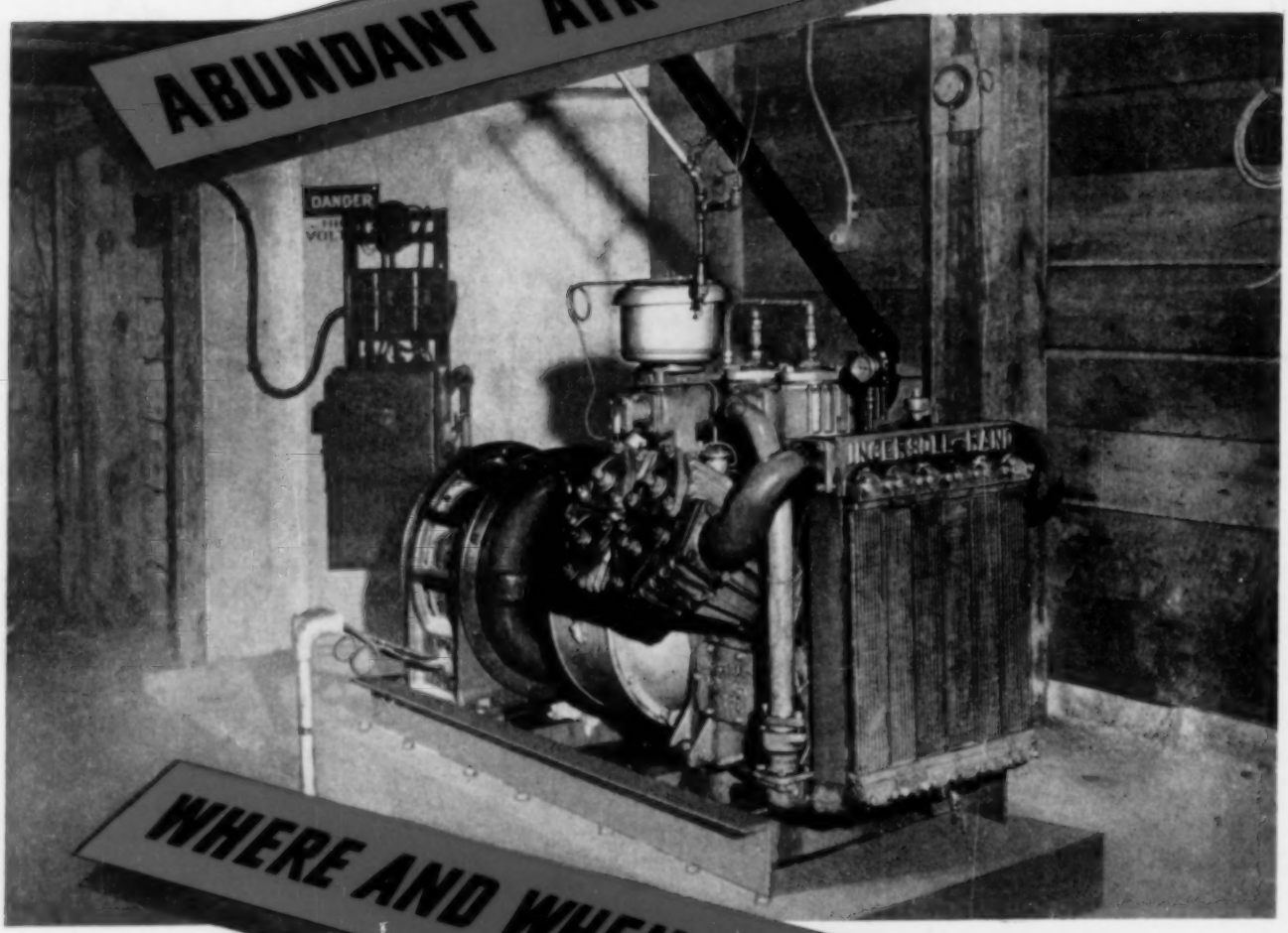
ABUNDANT AIR POWER



WHERE AND WHEN YOU NEED IT!

Tough mining operations which require an abundant and constant supply of compressed air, always proceed according to schedule where Timken Bearing Equipped compressors are used.

The photograph shows a "Timken Bearing Equipped" Ingersoll-Rand Type 40, 50 h.p. compressor installed at an Idaho mining property to equalize the low points in the curve of pressure in certain parts of the mine.

Timken Bearings are used on the crankshaft of this model—as they are in many Ingersoll-Rand compressors—to promote maximum smoothness of operation, to prevent crankshaft wear, to protect the crankshaft against radial, thrust and combined loads and to hold it in correct alignment. As a result, lubrication is simplified, endurance is increased, compressor life is prolonged and maintenance costs are greatly reduced.

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